Engineering and Technical Services for Joint Group on Acquisition Pollution Prevention (JG-APP) Pilot Projects

Joint Test Protocol LM-P-1-2

for Validation of Alternatives to Solvent-Based Ink Stenciling for Identification Marking

March 11, 1997

Contract No. DAAA21-93-C-0046
Task No. N.072
CDRL No. A005

Prepared by
National Defense Center for Environmental Excellence (NDCEE)

Operated by Concurrent Technologies Corporation (CTC)

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PREFACE

This report was prepared by Concurrent Technologies Corporation (*CTC*) through the National Defense Center for Environmental Excellence (NDCEE). This report was prepared on behalf of, and under guidance provided by, the Joint Group on Acquisition Pollution Prevention (JG-APP) through the Joint Pollution Prevention Advisory Board (JPPAB). The structure, format, and depth of technical content of the report was determined by the JPPAB, Government contractors, and other Government technical representatives.

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1. INTRODUCTION

On September 15, 1994, the Joint Logistics Commanders (JLCs) chartered the JG-APP to coordinate joint service activities affecting pollution prevention issues identified during a weapon system's acquisition process. The primary objectives of the JG-APP are:

- to reduce or eliminate Hazardous Materials (HazMats) by fostering joint service cooperation
- to avoid duplication of efforts in actions required to reduce or eliminate HazMats and share technology

The focus of JG-APP is on contractor design, manufacturing, and remanufacturing locations with technology transfer to the Sustainment Community.

This Joint Test Protocol (JTP) contains the critical requirements and tests necessary to qualify potential alternatives to a selected target HazMat and process for a particular application.

A Joint Test Report (JTR) will document the data and results of the testing and will be made available as a reference for future pollution prevention efforts by other Department of Defense (DoD) and commercial users to minimize duplication of effort.

At the Lockheed Martin Electronics & Missiles Company and Information Systems Company (Lockheed Martin) pilot site in Orlando, Florida, volatile organic compounds (VOCs), such as methyl ethyl ketone (MEK) and toluene as found in epoxy resin-based inks, were identified as the target HazMats to be eliminated or reduced. These inks are used to stencil or stamp mechanical hardware and electronic components that are used in a broad spectrum of applications. Parts to be labeled include circuit boards prior to soldering, components that are exposed to oils and greases in engine rooms, assemblies inside of cabinets that may be wiped with alcohol for cleaning, and parts that are repaired in shops and thus are exposed to flux removers, solvents, and fuels. The surface to be labeled may be bare or painted metallics or nonmetallics.

The purpose of this JTP is to describe a series of tests for two potential alternatives to the currently used epoxy resin-based inks: alternative stenciling inks and self-adhesive labels. Table 1 summarizes the target HazMats, the related process and application, current specifications, affected programs, and candidate parts and substrates.

Table 1. Lockheed Martin Target HazMat Summary

Target HazMat	Current Process	Applications	Current Specifications	Affected Programs	Candidate Parts/ Substrates
VOCs (Toluene and MEK) as used in Ink Stenciling	2 part epoxy Ink Stenciling Process	Marking	MIL-STD-130 MIL-STD-129 MIL-HDBK-454 Rqmt 67 MIL-M-81531 MIL-M-87958 MIL-PRF-61002 MIL-I-43553 MIS-20238 MIS-19916 MIS-22043	Air Force: ALS, CECOM, CVI, F-22 MLD, IVACC, LANTIRN, PT2000, WCMD, Gunship LLLTV Army: AGTS, COFT, FCR, LAV, PNVS, TADS, TDT, Comanche, Hellfire II, Javelin, Longbow, Longbow Missile, Patriot Foreign: AV-8B COFT (SAUDI/ KUWT), HAGS, Hellfire II Marines: AN/AAS-18, Predator NASA: ET Navy: AEGIS, ALS, CASS Lot4, CASS Lot5+, DDG, F/A-18, IRST-F-14, RPCP, UEC	Components for a broad spectrum of applications such as electronics cabinets and cabinet parts; aluminum, steel, and stainless steel sheet and parts; and nonmetallics, painted metal surfaces, and elastomers

2. ENGINEERING, PERFORMANCE, AND TESTING REQUIREMENTS

A joint group, led by JG-APP and consisting of technical representatives from Lockheed Martin, the affected DoD Program Managers, representatives of the Sustainment Community , and other government technical representatives, reached technical consensus on engineering, performance, and testing requirements. These requirements were identified for replacing high VOC-based epoxy inks used for identification stenciling and stamping with alternatives such as self-adhesive labels, or alternative inks where labeling is not possible. This joint group then defined critical tests with procedures, methodologies, and pass/fail criteria to qualify alternatives against these technical requirements.

For the purpose of this JTP, "identification marking" refers to identifying part information which includes, but is not limited to, part identifying numbers (PIN), vendor codes, Commercial and Government Entity (CAGE) codes, NATO Supply Code for Manufacturers (NSCM), and serial numbers.

Tests should be conducted in a manner that will eliminate duplication and maximize use of each test coupon. For example, where possible, more than one test should be performed on each panel. The number of tests that can be run on any one panel will be determined by the destructiveness of the test.

2.1. Groups of Engineering, Performance, and Testing Requirements

The test requirements for identification marking alternatives have been divided into three grades based upon performance requirements. For ease of discussion the three grades are designated as A, B, and C.

- **Grade A** performance specification requires that the marking be able to withstand extremes in environmental conditions and represents the most severe set of performance conditions a unit might be expected to encounter. These markings would typically be found on the exterior of a product that was expected to be used outdoors.
- **Grade B** performance specification requires that the marking be able to withstand typical operating environments of electronic equipment. These markings would typically be found on products that are used in an indoor, protected environment.
- **Grade C** performance specification requires that there is no significant consequence if the marking is removed in the future after the purpose for the original marking is fulfilled. Furthermore, the loss of the marking does not impact safety or preclude continued operational performance. Materials meeting the

Grade C test requirements are expected to be commercial off-the-shelf (COTS) labels. Examples of such labels include bag-&-tag applications and re-marking of vendor-supplied parts.

It is recognized that some programs require all three of these categories, while other programs may need only one. In general, the Grade C test categories are common to all programs and these would be the minimum requirements for any application.

For Grade A, B, and C categories, "common" and "extended" engineering, performance, and testing requirements were identified. "Common" requirements are essential to all weapon systems that are identified in Table 1, whereas tests related to "extended" requirements will be performed only as required by specific weapon systems. The identified "common" requirements and tests are listed in Section 2.2 and the identified "extended" requirements and tests are listed in Section 2.3. Each of the tests are identified with one or more of the above grades, as shown in Tables 2 and 3. The test methodologies are discussed in detail in Section 3.1 through Section 3.3.

2.2. Summary of Common Engineering, Performance, and Testing Requirements for Marking Applications

The common performance requirements and related tests for identification markings are listed in Table 2. These tests are required by all weapon systems identified in Table 1. Note that each of the tests are identified with specific Grades of parts (refer to Section 2.1) and applications. Applications that require testing include alternative stenciling inks (tests for "Ink on Part") and self-adhesive labels (tests for "Ink on Label" and "Label on Part").

Table 2. Common Engineering, Performance, and Testing Requirements for Marking Applications

Performance Requirement	JTP Sections	Acceptance Criteria	Variations of Test	Grade A	Grade B	Grade C	Applicability			Reference(s)
							Ink on Part	Ink on Label	Label on Part	
Abrasion (Scrub) Resistance	3.1.1 3.2.1	Legibility	--	X	X	X	X	X		MIL-M-81531 (May 2, 1967)
Adhesion	3.1.2 3.2.2	Legibility	--	X	X	X	X	X		ASTM D 3359-92a (May 15, 1992)
	3.3.1	Average pull value of 16 ounces per linear inch	--	X	X	X			X	ASTM D 3330-90 (June 29, 1990)
Chemical Resistance	3.1.3 3.2.3 3.3.2	Adhesion and/or legibility Inspect visually for any effects	Soak in:							ASTM D 896-92 (July 15, 1992)
			- Isopropyl alcohol	X	X	X	X	X	X	
			- Deionized water	X	X	X	X	X	X	
			- Engine oil 21SAE20W	X	X	X	X	X	X	
			- Terpene-based solvent	X	X		X	X	X	MIL-I-43553B (June 23, 1994)
Legibility	3.1.8 3.2.6	Visually discernible printing with 20/20 corrected vision	--	X	X	X	X	X		None

Table 2. Common Engineering, Performance, and Testing Requirements for Marking Applications (continued)

Performance Requirement	JTP Sections	Acceptance Criteria	Variations of Test	Grade A	Grade B	Grade C	Applicability			Reference(s)
							Ink on Part	Ink on Label	Label on Part	
Salt Spray Resistance	3.1.9 3.2.7 3.3.6	Adhesion and/or legibility; No effects on the label	48 hour exposure	X			X	X	X	ASTM B 117-94 (February 15, 1994)
		Corrosion no worse than control specimen	168 hour exposure	X			X	X	X	
Temperature Exposure and Thermal Shock Resistance	3.1.10 3.2.8 3.3.7	Adhesion and/or legibility	Low temperature exposure	X	X	X	X	X	X	MIL-M-87958 (October 12, 1990)
			High temperature exposure	X	X	X	X	X	X	
			Thermal shock	X	X	X	X	X	X	
UV Light/ Condensation	3.1.11 3.2.9 3.3.8	Adhesion and/or legibility; Label stays on test specimen	--	X	X		X	X	X	ASTM G 53-91 (September 15, 1991)

2.3. Summary of Extended Engineering, Performance, and Testing Requirements for Marking Applications

The extended test requirements for validating alternatives to ink stenciling for identification marking are in Table 3. These tests are in addition to the tests identified in Table 2 and will be performed as needed by specific weapon systems. Note that each of the tests are identified with specific grades of parts (refer to Section 2.1) and applications. Applications to be tested include alternative stenciling inks (tests for "Ink on Part") and self-adhesive labels (tests for "Ink on Label" and "Label on Part").

Table 3. Extended Performance and Testing Requirements for Marking Applications

Performance Requirement	JTP Sections	Acceptance Criteria	Variations of Test	Grade A	Grade B	Grade C	Applicability			Reference(s)
							Ink on Part	Ink on Label	Label on Part	
Adhesion (Program-specific parts)	3.3.1	Average pull value of 16 ounces per linear inch	--	(*)	(*)	(*)			X	ASTM D 3330-90 (June 29, 1990)
Chemical Resistance (Program-specific requirement)	3.1.3 3.2.3 3.3.2	Adhesion and/or legibility Inspect visually for any effects	Soak in: - Coolanol - PAO - Hydraulic fluid (MIL-H-5606) - Lubricating oil (MIL-L-23699) - Skydrol - JP5 (MIL-T-5624) - DS2	(*)	(*)	(*)	 X X X X X X X	 X X X X X X X	 X X X X X X X	ASTM D 896-92 (May 15, 1992)
Corrosivity	3.1.4 3.3.3	No visible signs of corrosion		X	X	X	X		X	ASTM D 3310-90 (March 30, 1990)
DC Electrical Resistance	3.1.5 3.3.4	Resistance ≥ 10^{12} ohms		X	X	X	X		X	ASTM D 257-92 (December 1992)
Fungus Resistance	3.1.6 3.2.4	Adhesion and/or legibility		X	X		X	X		MIL-STD-810E, Method 508 (July 14, 1989) MIL-HDBK-454 Guide-line 4 (April 28, 1995)

(*) Dependent on program-specific requirements.

Table 3. Extended Performance and Testing Requirements for Marking Applications (continued)

Performance Requirement	JTP Sections	Acceptance Criteria	Variations of Test	Grade A	Grade B	Grade C	Applicability			Reference(s)
							Ink on Part	Ink on Label	Label on Part	
IR Reflectance	3.1.7 3.2.5 3.3.5	450-500 nm ≤ 8% reflectance 500-600 nm ≤ 10% reflectance 600-2700 nm ≤ 8% reflectance	Aircraft	X			X	X	X	MIL-C-85295B (October 22, 1990)
		Refer to Sections 3.1.7, 3.2.5, and 3.3.5	Ground Support Equipment	X			X	X	X	MIL-C-46168D (May 21, 1993)
Temperature Exposure and Thermal Shock Resistance (Program-specific parts)	3.3.7	Adhesion	Low temperature exposure	(*)	(*)	(*)			X	MIL-M-87958 (October 12, 1990)
			High temperature exposure	(*)	(*)	(*)			X	
			Thermal shock	(*)	(*)	(*)			X	

(*) Dependent on program-specific requirements.

3. TEST DESCRIPTIONS

Tests identified in Tables 2 and 3 are discussed in this section. The discussion includes a description of the test, the reason the test is necessary, test methodologies, and any unique equipment and instrumentation and data analysis, as needed. Test methodology includes the definition of test parameters, test specimens, test trials, and pass/fail criteria.

Below is a listing of substrate types that will be used for testing (test specimen code). In the case of the aluminum alloys, the temper of the alloy may be determined by the tester.

AL1	Aluminum alloy 2024, (QQ-A-250/4), cleaned, chromate conversion coated, primed, and topcoated.
AL2	Aluminum alloy, 6061-T6, (QQ-A-250/11), cleaned and chromate conversion coated.
SS	Stainless steel 302, (ASTM-A-240), cleaned.
NR	Neoprene rubber, (AMS 3208), scuff to remove mold release or other foreign coating, and clean by wiping with acetone per O-A-51.
SR	Silicone rubber, (AMS 3347), scuff to remove mold release or other foreign coating, and clean by wiping with acetone per O-A-51.
G/E	Glass/epoxy laminate, either custom fabricated in a suitable laboratory or purchased from a material supplier, and cleaned by solvent wiping with alcohol per TT-I-735A.
C/E	Carbon/epoxy laminate, either custom fabricated in a suitable laboratory facility or purchased from a material supplier, and cleaned by solvent wiping with acetone per O-A-51.
A/E	Aramid/epoxy laminate, (MIL-S-13949/15), unclad, cleaned by solvent wiping with acetone per O-A-51.

Unless otherwise stated, each test specimen should be stenciled or labeled prior to performance of the test. Initial qualification testing should be performed with black stenciling and printing inks unless otherwise stated. (This JTP may also be used in the future to test other colors.) Before stenciling or labeling, the cleanliness of each test panel will be measured with an Omegameter. The test panels may have a maximum contaminant level of 1.56 µg/cm^2; the acceptance criteria is based on J-STD-001B (*Joint*

Industry Standard. Requirements for Soldered Electrical and Electronic Assemblies, issued January 1995). The required pattern and orientation for all labels and stenciling inks to be tested are shown in Appendices A and C. Note that the size of the test specimen will be approximately 5.25 inches by 4.25 inches and two markings or labels (each approximately 1.75 inches by 4.75 inches) will be placed on each specimen. The alphanumerics will be in 10 point Arial font.

3.1. Test Descriptions for Alternative Inks; Testing the Inks on the Test Specimens

Test procedures that should be performed to test each candidate stenciling ink are presented in Sections 3.1.1 through 3.1.11. The orientation and pattern of all test specimens is shown in Appendix A. In addition to the alternative stenciling inks, a currently used two-component epoxy stenciling ink (on an AL1 panel) should be evaluated as a control for all tests in Sections 3.1.1 through 3.1.11.

3.1.1. Abrasion (Scrub) Resistance Test

Test Description

This test will be used to determine if the alternative identification marking method has appropriate abrasion resistance.

Place the test specimen upon a flat work surface and rub each of the two stenciled markings with a flat surface of an eraser conforming to the regular grade of A-A-132B (*Erasers,* issued December 10, 1992). Twenty rubs should be made the entire length of the marking with firm pressure on the eraser. The eraser should be at least 3/8 inches wide. The rate of rubs should be about 2 to 3 seconds for each rub. Inspect the marking for legibility in accordance with Section 3.1.8.

Rationale

Two methods were identified that addressed abrasion resistance: the Tabor wheel and the rub test. The rub test was chosen over the Tabor wheel because it is similar to the abrasion test currently used for qualifying new marking materials under Paragraph 4.6.2 of MIL-M-81531 (*Marking of Electrical Insulating Materials,* issued May 2, 1967).

Test Methodology

Parameters	Twenty rubs of eraser per stenciled marking
Type and Number of Test Specimens per Alternative Stenciling Ink	3 AL1, 3 AL2, 3 SS, 3 SR (*), 3 NR, 3 G/E, 3 C/E, 3 A/E
Acceptance Criteria	Legibility per Section 3.1.8

(*) Silicone rubber (SR) substrates will only be used when testing silicone-based ink. However, silicone-based ink may be applied to other substrate types.

Unique Equipment and Instrumentation

- Eraser that conforms to A-A-132B

3.1.2. Adhesion Test

Test Description

This adhesion test will measure the ability of a stenciling ink to adhere to a test specimen. The adhesion will be measured with a standard tape test.

Perform this test procedure in accordance with Method A of ASTM D 3359-92a (*Standard Test Methods for Measuring Adhesion by Tape Test*, approved May 15, 1992), except use a roller instead of finger pressure to adhere the tape.

Scribe an "X" into the stenciled area. Each line of the "X" should be approximately 1.5 inches long and the lines should intersect near the centers with a 30 to 45° angle between them. (Refer to Appendix D for the placement of the "X".) Place a piece of tape across the center of the "X". Smooth the tape down with a 4.5 pound roller to ensure adherence. Within 90 ± 30 seconds of application, rapidly remove the tape by pulling it back upon itself at as close to a 180° angle as possible. Inspect the stenciled area for legibility per Section 3.1.8.

Rationale

ASTM D 3359-92a was chosen because it is a widely used, general tape test. Method A of ASTM D 3359-92a is primarily for job sites, while Method B is for laboratory use only. Method A uses a standard "X" pattern, while Method B uses a lattice. Method A was chosen over Method B because it is consistent with the current test used to qualify the adhesion of paints for the DoD.

In Method A of ASTM D 3359-92a, the tape is smoothed down with a finger. A roller is specified in this procedure for smoothing down the tape instead of finger pressure because the pressure is more likely to be constant across the marking and constant for all test specimens.

Test Methodology

Parameters	
Type and Number of Test Specimens per Alternative Stenciling Ink	3 AL1, 3 AL2, 3 SS, 3 NR, 3 SR (*), 3 G/E, 3 C/E, 3 A/E
Acceptance Criteria	Legibility per Section 3.1.8

(*) Silicone rubber (SR) substrates will only be used when testing silicone-based ink. However, silicone-based ink may be applied to other substrate types.

Unique Equipment and Instrumentation

- 4.5 pound Roller
- Standard #250 Masking Tape

3.1.3. Chemical Resistance Test

Test Description

This test examines the legibility and adhesion of identification markings after exposure to selected chemicals.

Part A: Perform this chemical resistance test in accordance with ASTM D 896-92 (*Resistance of Adhesive Bonds to Chemical Reagents*, approved July 15, 1992), but replace the chemical reagents in the standard with those listed in Test Methodology.

Immerse test specimens in reagents as specified in Test Methodology. Recover and dry the specimens and test the markings for adhesion in accordance with Section 3.1.2 and legibility in accordance with Section 3.1.8.

Part B: Coat a test specimen with a thin film of RMA flux. Float the specimen in a solder bath and immerse in a terpene-based solvent as specified in Test Methodology. After immersion, inspect the specimens for adhesion in accordance with Section 3.1.2 and legibility in accordance with Section 3.1.8.

Rationale

The first part of this procedure is patterned after ASTM D 896-92. The selection of the chemical reagents was based on Test Method 215J of MIL-STD-202F (*Test Methods for Electronic and Electrical Component Parts*, issued January 31, 1996). MIL-STD-202F specifies isopropyl alcohol and deionized water. In addition, Lockheed Martin commonly uses isopropyl alcohol and deionized water for cleaning. Engine oil was added because it is representative of petroleum products used around Lockheed Martin's products. The chemical reagents listed for the extended tests (refer to Test Methodology) were identified by at least one program as a requirement.

The second part of this test procedure is performed in accordance with Section 4.6.3.2.1 of MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994) to measure the hot solder/flux chemical resistance, except the specimens are immersed in a terpene-based solvent for 3 minutes instead of 1 minute. The terpene-based solvent soak was increased from the 1 minute specified by MIL-I-43553B to 3 minutes to be consistent with the first part of the chemical soak test that is performed in accordance with ASTM D 896-92.

Test Methodology

Parameters	Part A: Immerse test specimens for 3 minutes at 23 ± 1.1°C (73.4 ± 2°F) in the following fluids: • Common tests: Isopropyl alcohol, deionized water, or engine oil (21SAE20W) • Extended tests: Coolanol, PAO, hydraulic fluid (MIL-H-5606), lubricating oil (MIL-L-23699), Skydrol, JP5 (MIL-T-5624), or DS2 Part B: • Float specimen, marking side up, on solder bath at 260 ± 5°C (500 ± 9°F) for 10 seconds • Cool to room temperature • Immerse in terpene-based solvent for 3 minutes
Type and Number of Test Specimens per Alternative Stenciling Ink	1 AL1, 1 AL2, 1 SS, 1 NR, 1 SR (*), 1 G/E, 1 C/E, 1 A/E (per chemical)
Acceptance Criteria	Adhesion per Section 3.1.2 and legibility per Section 3.1.8 Inspect visually for discoloration, wrinkling, cracking, smearing, or any other effects

(*) Silicone rubber (SR) substrates will only be used when testing silicone-based ink. However, silicone-based ink may be applied to other substrate types.

3.1.4. Corrosivity Test

Test Description

This test determines if a marking material is corrosive to a metal.

Perform this test procedure in accordance with ASTM D 3310-90 (*Standard Test Method for Determining Corrosivity of Adhesive Materials,* approved March 30, 1990).

Heat an oven to one of the temperatures listed in Test Methodology, choosing the temperature that is closest to the expected service

temperature. Place the test specimen into a glass jar. Place uncovered jar in a larger glass jar and screw a jar lid onto the larger jar. Heat jars in an oven for 7 days. Inspect visually for corrosion; record corrosion daily.

Rationale

This corrosivity test is an extended test for programs that require a test for corrosivity in addition to the salt spray resistance test in Section 3.1.9. This corrosivity test is patterned after ASTM D 3310-90. The highest test temperature of 244°F (118°C) was chosen to agree with MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994).

Test Methodology

Parameters	7 days at 244 ± 5°F, 160 ± 5°F, or 130 ± 5°F
Type and Number of Test Specimens per Alternative Stenciling Ink	1 AL1, 1 AL2, 1 SS
Acceptance Criteria	No visible signs of corrosion

Unique Equipment and Instrumentation

- Glass jars with screw caps and cups or open jars
- Forced Draft Circulating Air Oven

3.1.5. DC Electrical Resistance Test

Test Description

Measuring the electrical resistance of inks ensures that the alternative marking materials will not create short circuits between electronic components.

Perform this DC electrical resistance test in accordance with ASTM D 257-92 (*Standard Test Method for D-C Resistance or Conductance of Insulating Materials*, approved July 15, 1992, reissued December 1992).

Mount the test specimen in a test chamber and apply 500 ± 5 V to the specimen for 60 seconds. Directly measure the voltage drop across the test specimen with a current-measuring device (e.g., electrometer, DC amplifier with indicating meters, or galvanometer). Calculate the surface and volume resistivity using the measured voltage drop and the specimen

and electrode dimensions. The test environment should be at standard conditions (25 ± 5°C and relative humidity of 50 ± 20 percent). Note that surface contamination will affect the results of this test, so it is important to use the cleanliness test specified in Section 3.

Rationale

This test is performed in accordance with ASTM D 257-92. The test methodology is similar to the test methodology of Paragraph 4.6.2.4 of MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994). Volume resistance is calculated in addition to surface resistance because some degree of volume resistance is always involved.

Test Methodology

Parameters	500 ± 5 V for 60 seconds
Number and Type of Test Specimens per Alternative Stenciling Ink	3 G/E
Acceptance Criteria	Resistance ≥ 10^{12} ohms

Unique Equipment and Instrumentation

- Power source
- Current measuring device (e.g., electrometer, DC amplifier with indicating meters, or galvanometer)

3.1.6. Fungus Resistance Test

Test Description

The fungus resistance of the marking material will be measured with this test procedure.

Prepare cultures of *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus versicolor*, and *Penicillium fungiculosum* on an appropriate medium such as potato dextrose agar. Culture *Chaetomium globosum* on strips of filter paper overlaid on the surface of a mineral salts agar that consists of agar and a mineral salts solution of the following composition:

	Quantity
Potassium dihydrogen orthophosphate	0.7 gram
Potassium monohydrogen orthophosphate	0.7 gram
Magnesium sulfate heptahydrate	0.7 gram
Ammonium nitrate	1.0 gram
Sodium chloride	0.005 gram
Ferrous sulfate heptahydrate	0.002 gram
Zinc sulfate monohydrate	0.002 gram
Distilled water	1000 milliliters

Prepare a spore suspension by pouring 10 milliliters of an aqueous solution containing 0.05 grams per liter of a nontoxic wetting agent (e.g., sodium dioctyl sulfosuccinate or sodium lauryl sulfate) onto each agar culture, and then pouring the mixture into an Erlenmeyer flask that contains 45 milliliters of water and 50 to 75 glass beads that have a 5 millimeter diameter. Shake the flask. Filter the mixture with glass wool to remove the large mycelial fragments and clumps of agar. Resuspend the spores three additional times, filtering each time. After the final rinsing, suspend the spores in the mineral salts solution (composition previously described), so that the solution has 1,000,000 ± 200,000 spores per milliliter as determined with a counting chamber. Verify the viability of the spore suspension by incubating an inoculated potato dextrose agar plate at 75 to 88°F (24 to 31°C) for 7 to 10 days and checking for fungal growth. If fungal growth does not occur, the fungal suspensions must be prepared again.

Prepare the final mixed spore suspension by combining equal volumes of each fungal suspension. Prepare an environmental chamber that has 95 ± 5 percent humidity at 86 ± 2°F (30 ± 1°C), with an air velocity between 98 and 335 feet per minute (0.5 and 1.7 meters per second). Place the test specimens and cotton strips (used for a control) in the environmental chamber for at least 4 hours immediately prior to inoculation. Inoculate the specimens with the final mixed spore suspension by spraying a mist of the suspension with an atomizer or nebulizer. After 7 days of inoculation, the cotton strips should be at least 90 percent covered with fungal growth; if not, repeat the entire test. After a total of 84 days, remove the test specimens. Evaluate the ink adhesion and legibility in accordance with Sections 3.1.2. and 3.1.8., respectively.

Rationale

This test will be performed to measure the extent to which the alternative stenciling inks will support fungal growth and how the fungal growth affects the legibility and adhesion of the inks on non-nutrient substrates.

This fungus resistance test is performed in accordance with Method 508 of MIL-STD-810E (*Department of Defense Test Method Standard for Environmental Considerations and Laboratory Tests*, issued July 14, 1989), except the test duration is different. This test procedure will not be required if the ink is listed as an inert material in Guideline 4 of MIL-HDBK-454 (*General Guidelines for Electronic Equipment*, issued April 28, 1995).

Method 508 of MIL-STD-810E recommends that the minimum test duration is 28 days, but suggests a longer test duration of 84 days to allow for fungal germination, breakdown of organic compounds, and degradation of the material being tested. Therefore, the longer test duration was selected for this procedure.

Test Methodology

Parameters	5 types of fungi/84 days/95 ± 5% RH/ 86 ± 2°F
Type and Number of Test Specimens per Alternative Stenciling Ink	1 AL2
Acceptance Criteria	Legibility per Section 3.1.8 and adhesion per Section 3.1.2

Unique Equipment and Instrumentation

- Environmental Chamber
- 125-W Heating Coil
- Psychrometer
- Counting Chamber
- Atomizer or nebulizer

3.1.7. IR Reflectance Test

Test Description

This testing method measures the infrared (IR) reflectance of a marking material.

Prepare the test specimen by covering the entire panel with the stenciling ink. Measure the total reflectance (specular and diffuse) of the test specimen within the wavelength range relative to barium sulfate using a Perkin-Elmer LAMBDA 9 spectrophotometer or equivalent.

Compare the reflectance value with the acceptance criteria. Aircraft and ground support equipment that use aircraft colors must comply with the "Aircraft" acceptance criteria listed in Test Methodology. Black (Color 37030 of FED-STD-595B (*Colors Used in Government Procurement*, issued December 15, 1989) or Green 383 (Color 34094 of FED-STD-595B) stenciling inks that will be used on the exterior of ground support equipment may be required to comply with the "Ground Support Equipment" acceptance criteria in Test Methodology.

Rationale

When a marking is on the exterior of aircraft or ground support equipment, the IR reflectance of the marking can critical. Several programs agreed that an alternative stenciling ink that will be used on aircraft must comply with the IR reflectance criteria in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990). The "Aircraft" acceptance criteria is that of MIL-C-85285B.

The two colors selected for ground support equipment are the only non-aircraft colors that will be used on the exterior of ground support equipment. The acceptance criteria for these colors are based on MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993).

Test Methodology

Parameters	**Aircraft**	**Ground Support Equipment**
Type and Number of Test Specimens per Alternative Stenciling Ink	3 AL1 (*)	2 AL1 (**)
Acceptance Criteria	450-500 nm ≤ 8% reflectance 500-600 nm ≤ 10% reflectance 600-2700 nm ≤ 8% reflectance	Black (37030 of FED-STD-595B) ≤ 15% reflectance at wavelengths listed in Table 4 Green 383 (34094 of FED-STD-595B): refer to Table 5

(*) One test specimen per wavelength range.
(**) One test specimen for each color.

Table 4. Selected Wavelengths for Determining IR Reflectance Values of Spectrophotometric Curves for Black (37030 of FED-STD-595B) Alternative Stenciling Inks (in nanometers)

714	769	816
725	773	821
730	777	826
737	783	831
742	787	836
747	793	842
751	797	848
756	802	855
760	807	862
764	811	873

Table 5. Acceptance Criteria for IR Reflectance of Green 383 (34094 of FED-STD-595B) Alternative Stenciling Inks

Wavelength	**% Reflectance**	
	Maximum	**Minimum**
600	10.2	--
610, 620, 630	9.8	--
640, 650	9.5	--
660	10.0	--
670	10.5	4.0
680	13.0	5.8
690	21.5	8.5
700	28.0	11.0
710	35.8	15.0
720	41.0	19.0
730	48.5	25.0
740	51.8	30.0
750	56.0	36.3
760	59.5	40.0
770	61.5	42.0
780, 790, 800, 810, 820, 830, 840, 850, 860, 870, 880, 890, 900	--	42.0

Unique Equipment and Instrumentation

- Perkin-Elmer LAMBDA 9 spectrophotometer (or equivalent)

3.1.8. Legibility Test

Test Description

A legibility test is necessary to ensure that the alternative identification method produces a readable marking.

At a lighting of at least 50 candela, examine test specimens at 18 inches minimum distance with 20/20 corrected vision. The test specimen is described in Appendix A and uses a 10 point Arial font.

Rationale

A national standard was not used to develop this test procedure. The basis of the legibility test was derived from a discussion between Lockheed Martin, Texas Instruments Defense Systems & Electronics, and the program technical representatives. The 10 point font was selected because it was perceived as a standard for typed alphanumerics on markings. The lighting intensity was selected as a number that is below the Occupational Safety and Health Administration (OSHA) workplace minimums. The distance from the test specimen (i.e., 18 inches) was referenced to Lockheed Martin standards and, therefore, agreed upon by the group.

Test Methodology

Parameters	18 inches minimum distance; At least 50 candela
Number and Type of Test Specimens per Alternative Stenciling Ink	3 AL1 (White topcoat with black inks. Topcoats must contrast with ink.)
Acceptance Criteria	Visually discernible printing with 20/20 corrected vision

3.1.9. Salt Spray Resistance Test

Test Description

This salt spray test measures the effect that corrosion has on the legibility of a marking and the adhesion of an ink. In addition, it compares the amount of corrosion that occurs on a marked test specimen with the corrosion on a control specimen.

Perform this test procedure in accordance with ASTM B 117-94 (*Standard Practice for Operating Salt Spray (Fog) Testing Apparatus*, approved February 15, 1994).

Place the test specimens and a control panel of AL2 (not stenciled, for Part B of this test only) into a fog chamber. The test specimens may not contact the chamber walls or each other. Prepare a salt solution and the fog chamber as specified in Test Methodology. Set the nozzles in the fog chamber so that sprayed salt solution does not directly contact the test specimens.

Part A: Operate the fog chamber continuously for 48 hours. At the end of the test duration, carefully remove the specimens. Clean the specimens by gently flushing them with running tap water, and dry them with a stream of clean, compressed air. Evaluate the legibility of the marking and the adhesion of the ink on the test specimen in accordance with Section 3.1.8 and Section 3.1.2, respectively.

Part B: Operate the fog chamber continuously for 168 hours. At the end of the test duration, carefully remove the specimens. Clean the specimens by gently flushing them with running tap water, and dry them with a stream of clean, compressed air. Compare the amount of corrosion on the test specimen to that of the control specimen.

Rationale

A salt spray test is necessary because it will evaluate the additional corrosion potential created by a marking. A salt spray test is required by MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994). The test in this JTP is performed in accordance with ASTM B 117-94, which is a standard salt spray (fog) test.

The duration of Part A of this test was derived from MIL-I-43553B, which requires that an epoxy ink is functional after 48 hours immersion in 20 percent salt solution. The duration of Part B of the test (168 hours) is the duration of a salt spray test for MIL-C-5541E (*Chemical Conversion Coatings on Aluminum and Aluminum Alloys,* issued November 30, 1990), and is used as a standard for this test because the AL2 control specimen should not corrode during this time period.

Test Methodology

Parameters	• Test specimen at a 15-30° angle • Temperature of exposed salt spray zone = 95 + 2 - 3°F • Every 80 cm^2 horizontal area, two collectors gather 1.0-2.0 mL fog/h • 5% salt solution (5 ± 1 parts by weight of NaCl in 95 parts of water) • pH = 6.5-7.2 when atomized at 95°F (35°C) • 48 and 168 hours
Number and Type of Test Specimens per Alternative Stenciling Ink	4 AL1 (*), 4 AL2 (*), 4 G/E (*); 1 Control specimen of AL2 (not stenciled, for Part B only)
Acceptance Criteria	After 48 hours: Legibility per Section 3.1.8 and adhesion per Section 3.1.2 After 168 hours: Corrosion no worse than control specimen of AL2 (not stenciled)

(*) Three test specimens for Part A (48 hour test); one test specimen for Part B (168 hour test).

Unique Equipment and Instrumentation

- Fog Chamber
- Salt Solution Reservoir
- Compressed Air Supply
- Atomizing Nozzles
- Heater for the Fog Chamber

3.1.10. Temperature Exposure and Thermal Shock Resistance Tests

Test Description

To measure the resistance of the marking to degradation upon extreme temperature exposure or thermal shock, perform three tests: low temperature exposure, high temperature exposure, and thermal shock. Note that the appropriate test temperature must be selected in accordance with the final use of the part; the temperatures used for the temperature exposure and thermal shock tests should be close to the expected service temperature.

1. **Low Temperature Exposure**. Place test specimens into a cold chamber at -55 ± 5°F or -40 ± 5°F for 30 minutes. After the test duration, remove the test specimens and inspect them within 30 minutes for legibility per Section 3.1.8 and adhesion per Section 3.1.2.

2. **High Temperature Exposure**. Place test specimens in a circulating air oven for 30 minutes. The temperature of the oven will be either 244 ± 5°F, 160 ± 5°F, or 130 ± 5°F. After the test duration, cool the test specimens at room temperature for 30 minutes. Inspect the legibility of the marking per Section 3.1.8 and the adhesion of the ink per Section 3.1.2.

3. **Thermal Shock Test**. Expose the test specimen to -55 ± 5°F or -40 ± 5°F for 30 minutes in a cold chamber. Remove the test specimen from the cold chamber and transfer it to an oven at 244 ± 5°F, 160 ± 5°F, or 130 ± 5°F within one minute. Remove the test specimen from the oven after 30 minutes. Within 30 minutes after removal from the oven, inspect the marking for legibility per Section 3.1.8 and the ink for adhesion per Section 3.1.2.

Rationale

This test measures the ink's ability to withstand a large range of temperatures. The high and low temperature exposure tests were patterned from MIL-M-87958 (*Marker Blanks, Pressure Sensitive Adhesive Wire or Cable Marker and Identification Labels*, issued October 12, 1990), Paragraphs 4.6.5.1 and 4.6.5.2, respectively. MIL-M-87958 is for wire or cable marker self-adhesive labels, but it has been modified for this application. The thermal shock resistance test was developed by Lockheed

Martin and technical representatives as a standard test to measure the ability of the marking material to withstand a rapid temperature change.

The high service temperature of 244°F (118°C) was chosen to agree with MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994). The duration of the tests was reduced from the MIL-M-87958 requirement because the test specimens are simple, have low thermal mass, and would not require the 4 hour (low temperature exposure) and 168 hour (high temperature exposure) test duration to obtain the desired test specimen temperature. Thirty minute test durations are believed to be sufficient by Lockheed Martin and technical representatives. Additionally, a corrosivity test (Section 3.1.4) is available for a high temperature resistance test with a longer duration.

Test Methodology

Parameters	• Low temperature exposure (-55°F or -40°F for 30 minutes) • High temperature exposure (130°F, 160°F, or 244°F for 30 minutes) • Thermal shock resistance (-55°F or -40°F for 30 minutes then 130°F, 160°F, or 244°F for 30 minutes)
Number and Type of Test Specimens per Alternative Stenciling Ink	3 AL1(*)
Acceptance Criteria	Legibility per Section 3.1.8 and adhesion per Section 3.1.2

(*) One test specimen for the low temperature exposure test; one test specimen for the high temperature exposure test; and one test specimen for the thermal shock test.

Unique Equipment and Instrumentation

- Cold chamber(s) capable of maintaining -55 ± 5°F and -40 ± 5°F
- Oven(s) capable of maintaining 130 ± 5°F, 160 ± 5°F, and 244 ± 5°F

3.1.11. UV Light/Condensation Exposure Test

Test Description

This test measures the effects of moisture, temperature, and ultraviolet (UV) light on a marking material.

Perform this test in accordance with the procedure specified in ASTM G 53-91 (*Standard Practice for Operating Light and Water-Exposure Apparatus (Fluorescent UV-Condensation Test) of Exposure of Nonmetallic Materials*, approved September 15, 1991).

Position the test specimens in the test chamber so that the markings are facing the lamp. The test specimens are exposed for a total of 96 hours using an 8-hour repeating program cycle of 4 hours of UV light at 140°F (60°C) followed by 4 hours of condensation at 122°F (50°C). Rotate the test specimens every 24 hours to ensure that all specimens spend approximately the same exposure time near the center of the exposure area. After the test duration, remove the test specimens and evaluate the markings for legibility per Section 3.1.8 and the ink for adhesion per Section 3.1.2.

Rationale

A UV light/condensation test is necessary to identify deleterious effects on stenciling inks that may be used in outside environments. A 96 hour test duration was selected because it is the lower limit specified in ASTM G 53-91 and it is expected that any detrimental effects will show up during this duration.

Test Methodology

Parameters	Total exposure of 96 hours using an 8-hour repeating program cycle of 4 hours of UV light at 140°F (60°C) followed by 4 hours of condensation at 122°F (50°C)
Number and Type of Test Specimens per Alternative Stenciling Ink	3 AL1
Acceptance Criteria	Legibility per Section 3.1.8 and adhesion per Section 3.1.2

Unique Equipment and Instrumentation

- Test chamber with eight fluorescent UV lamps, a heated water pan, racks, and controls (for UV Light Test)
- Conditioning cabinets or ovens (for Condensation Test)

3.2. Test Descriptions for Self-Adhesive Labels; Testing the Inks on the Label Substrates

The performance of each down-selected printing ink tested will largely depend upon the printing process employed. Therefore, inks selected for testing should be applied to the labels by the method(s) appropriate for regular use. In addition, the durability of the printing on the labels generally depends on the specific combination of ink, label material, and label coating used. A description of the test requirements for the different ink/printing process systems follows:

- *Dot matrix printers*—Each candidate ink for dot matrix printers will be tested on uncoated polyimide, polyester, polyvinyl fluoride, and paper labels. Two labels of the same material shall be placed onto an AL1 test coupon in the configuration shown in Appendix B.
- *Ink jet printers*—Each candidate ink for ink jet printers will be tested on uncoated polyimide, polyester, polyvinyl fluoride, and paper labels. In some cases, the ink may not be readily available in ink cartridges. A stenciled label will be considered to be representative of the ink jet printer process. Two labels of the same material shall be placed onto an AL1 test coupon in the configuration shown in Appendix B.
- *Laser printers*—Each candidate ink for laser printers will be tested on polyimide, polyester, and polyvinyl fluoride labels from each selected vendor. Two labels from the same vendor will be placed on an AL1 panel and tested. In addition, two marked labels from the same vendor will be placed onto another AL1 panel. The top label (with the black background) will be covered with a clear polyester label and the bottom label (with the white background) will be sprayed with a polyurethane coating. The configuration of the labels shall be the same as the example shown in Appendix B.
- *Thermal transfer printers*—Each candidate ink for thermal transfer printers will be tested on labels from each selected vendor. Each alternative thermal transfer ribbon will be used to print labels on

polyimide, polyester, or polyvinyl fluoride labels that are coated for thermal transfer printers. Two labels of the same material shall be placed onto an AL1 test coupon in the configuration in Appendix B.

- *Control specimen*—A control specimen will be tested for each performance requirement in Section 3.2. Each control specimen will consist of two stenciled labels on a panel of AL1 (in the configuration shown in Appendix B). The labels will be stenciled with a currently used two-part Type I MIL-I-43553B black epoxy ink.

Test procedures that should be performed to test these ink/printing process systems are described in Sections 3.2.1 through 3.2.9. Failure of the underlying test specimen shall not be considered evidence of failure of the printing ink/printing process system.

3.2.1. Abrasion (Scrub) Resistance Test

Test Description

This test will be used to determine if the alternative identification marking method has appropriate abrasion resistance.

Place the test specimen upon a flat work surface and rub each label on the specimen with the flat surface of an eraser conforming to the regular grade of A-A-132B (*Erasers,* issued December 10, 1992). Twenty rubs should be made the entire length of the label with firm pressure on the eraser. The eraser should be at least 3/8 inches wide. The rate of rubs should be about 2 to 3 seconds for each rub. Inspect the label for legibility in accordance with Section 3.2.6.

Rationale

Two methods were identified that addressed abrasion resistance: the Tabor wheel and the rub test. The rub test was chosen over the Tabor wheel because it is similar to the abrasion test currently used for qualifying new marking materials under Paragraph 4.6.2 of MIL-M-81531 (*Marking of Electrical Insulating Materials,* issued May 2, 1967).

Test Methodology

Parameters	Twenty rubs of eraser per label
Number of AL1 test specimens to be tested for each candidate ink/printer system (2 labels per test specimen)	3
Type of labels	Refer to Section 3.2
Acceptance Criteria	Legibility per Section 3.2.6

Unique Equipment and Instrumentation

- Eraser that conforms to A-A-132B

3.2.2. Adhesion Test

Test Description

This adhesion test will measure the ability of an ink to adhere to a label. The adhesion will be measured with a standard tape test.

Perform this test procedure in accordance with Method A of ASTM D 3359-92a (*Standard Test Methods for Measuring Adhesion by Tape Test*, approved May 15, 1992), except use a roller instead of finger pressure to adhere the tape.

Scribe an "X" into the label and substrate. Each line of the "X" should be approximately 1.5 inches long and the lines should intersect near the centers with a 30 to 45° angle between them. (Refer to Appendix E for the placement of the "X".) Place a piece of tape across the center of the "X". Smooth the tape down with a 4.5 pound roller to ensure adherence. Within 90 ± 30 seconds of application, rapidly remove the tape by pulling it back upon itself at as close to a 180° angle as possible. Inspect the label for legibility per Section 3.2.6. Failure of the label to adhere to the test specimen shall not be cause for rejection.

Rationale

ASTM D 3359-92a was chosen because it is a widely used, general tape test. Method A of ASTM D 3359-92a is primarily for job sites, while Method B is for laboratory use only. Method A uses a standard "X" pattern, while Method B uses a lattice. Method A was chosen over

Method B because it is consistent with the current test used to qualify the adhesion of paints for the DoD.

In Method A of ASTM D 3359-92a, the tape is smoothed down with a finger. A roller is specified in this procedure for smoothing down the tape instead of finger pressure because the pressure is more likely to be constant across the label and constant for all test specimens.

Test Methodology

Parameters	
Number of AL1 test specimens to be tested for each candidate ink/printer system (2 labels per test specimen)	3
Type of labels	Refer to Section 3.2
Acceptance Criteria	Legibility per Section 3.2.6

Unique Equipment and Instrumentation

- 4.5 pound Roller
- Standard #250 Masking Tape

3.2.3. Chemical Resistance Test

Test Description

This test examines the legibility and adhesion of identification markings after exposure to selected chemicals.

Part A: Perform this chemical resistance test in accordance with ASTM D 896-92 (*Resistance of Adhesive Bonds to Chemical Reagents*, approved July 15, 1992), but replace the chemical reagents in the standard with those in Test Methodology.

Immerse test specimens in reagents as specified in Test Methodology. Recover and dry the specimens. Test the marking for adhesion per Section 3.2.2 and legibility per Section 3.2.6.

Part B: Coat a new set of test specimens with a thin film of RMA flux. Float the test specimens in a solder bath and immerse in a terpene-based solvent as specified in Test Methodology. After immersion, test the marking for adhesion in accordance with Section 3.2.2 and legibility in accordance with Section 3.2.6.

Rationale

The first part of this procedure is patterned after ASTM D 896-92. The selection of the chemical reagents was based on Test Method 215J of MIL-STD-202F (*Test Methods for Electronic and Electrical Component Parts,* issued January 31, 1996). MIL-STD-202F specifies isopropyl alcohol and deionized water. In addition, Lockheed Martin commonly uses isopropyl alcohol and deionized water for cleaning. Engine oil was added because it is representative of petroleum products used around Lockheed Martin's products. Engine oil was also added because it is used in qualification testing by Critchley Inc., a label vendor. The chemical reagents listed for the extended tests (refer to Test Methodology) were identified by at least one program as a requirement.

The second part of this test procedure is performed in accordance with Section 4.6.3.2.1 of MIL-I-43553B (*Epoxy Base Marking Ink,* issued June 23, 1994) to measure the hot solder/flux chemical resistance, except the specimens are immersed in a terpene-based solvent for 3 minutes instead of 1 minute. The terpene-based solvent soak was increased from the 1 minute specified by MIL-I-43553B to 3 minutes to be consistent with the first part of the chemical soak test that is performed in accordance with ASTM D 896-92.

Test Methodology

Parameters	Part A: Immerse test specimens for 3 minutes at 23 ± 1.1°C (73.4 ± 2°F) in the following fluids: • Common tests: Isopropyl alcohol, deionized water, or engine oil (21SAE20W) • Extended tests: Coolanol, PAO, hydraulic fluid (MIL-H-5606), lubricating oil (MIL-L-23699), Skydrol, JP5 (MIL-T-5624), or DS2 Part B: • Float specimen, marking side up, on solder bath at 260 ± 5°C (500 ± 9°F) for 10 seconds • Cool to room temperature • Immerse in terpene-based solvent for 3 minutes
Number of AL1 test specimens to be tested for each candidate ink/printer system (2 labels per test specimen)	3 (per chemical)
Type of labels	Refer to Section 3.2
Acceptance Criteria	Adhesion test per Section 3.2.2 and legibility test per Section 3.2.6 Inspect marking visually to see if it is smeared or eroded. Also inspect visually for discoloration, wrinkling, or cracking

3.2.4. Fungus Resistance Test

Test Description

The fungus resistance of the ink/printing process system will be measured with this test procedure.

Prepare cultures of *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus versicolor*, and *Penicillium fungiculosum* on an appropriate medium such as potato dextrose agar. Culture *Chaetomium globosum* on strips of filter

paper overlaid on the surface of a mineral salts agar that consists of agar and a mineral salts solution of the following composition:

	Quantity
Potassium dihydrogen orthophosphate	0.7 gram
Potassium monohydrogen orthophosphate	0.7 gram
Magnesium sulfate heptahydrate	0.7 gram
Ammonium nitrate	1.0 gram
Sodium chloride	0.005 gram
Ferrous sulfate heptahydrate	0.002 gram
Zinc sulfate monohydrate	0.002 gram
Distilled water	1000 milliliters

Prepare a spore suspension by pouring 10 milliliters of an aqueous solution containing 0.05 grams per liter of a nontoxic wetting agent (e.g., sodium dioctyl sulfosuccinate or sodium lauryl sulfate) onto each agar culture, and then pouring the mixture into an Erlenmeyer flask that contains 45 milliliters of water and 50 to 75 glass beads that have a 5 millimeter diameter. Shake the flask. Filter the mixture with glass wool to remove the large mycelial fragments and clumps of agar. Resuspend the spores three additional times, filtering each time. After the final rinsing, suspend the spores in the mineral salts solution (composition previously described), so that the solution has 1,000,000 ± 200,000 spores per milliliter as determined with a counting chamber. Verify the viability of the spore suspension by incubating an inoculated potato dextrose agar plate at 75 to 88°F (24 to 31°C) for 7 to 10 days and checking for fungal growth. If fungal growth does not occur, the fungal suspensions must be prepared again.

Prepare the final mixed spore suspension by combining equal volumes of each fungal suspension. Prepare an environmental chamber that has 95 ± 5 percent humidity at 86 ± 2°F (30 ± 1°C), with an air velocity between 98 and 335 feet per minute (0.5 and 1.7 meters per second). Place the test specimens and cotton strips (used for a control) in the environmental chamber for at least 4 hours immediately prior to inoculation. Inoculate the specimens with the final mixed spore suspension by spraying a mist of the suspension with an atomizer or nebulizer. After 7 days of inoculation, the cotton strips should be at least 90 percent covered with fungal growth; if not, repeat the entire test. After a total of 84 days, remove the test specimens. Evaluate the ink adhesion and legibility in accordance with Sections 3.2.2 and 3.2.6, respectively.

Rationale

This test will be performed to measure the extent to which a printing ink will support fungal growth and how the fungal growth affects the legibility and adhesion of the ink on non-nutrient substrates. This fungus resistance test is performed in accordance with Method 508 of MIL-STD-810E (*Department of Defense Test Method Standard for Environmental Considerations and Laboratory Tests*, issued July 14, 1989), except the test duration is different. However, if the ink is listed as an inert material in Guideline 4 of MIL-HDBK-454 (*General Guidelines for Electronic Equipment*, issued April 28, 1995), this test procedure will not be required.

Method 508 of MIL-STD-810E recommends that the minimum test duration is 28 days, but suggests a longer test duration of 84 days to allow for fungal germination, breakdown of organic compounds, and degradation of the material being tested. Therefore, the longer test duration was selected for this procedure.

Test Methodology

Parameters	5 types of fungi/84 days/95 ± 5% RH/86 ± 2°F
Number of AL1 test specimens to be tested for each candidate ink/printer system (2 labels per test specimen)	1
Type of Labels	Refer to Section 3.2
Acceptance Criteria	Legibility per Section 3.2.6 and adhesion per Section 3.2.2

Unique Equipment and Instrumentation

- Environmental Chamber
- 125-W Heating Coil
- Psychrometer
- Counting Chamber
- Atomizer or nebulizer

3.2.5. IR Reflectance Test

Test Description

This testing method measures the infrared (IR) reflectance of a marking material.

Prepare the test specimen by covering the entire panel with the printing ink. Measure the total reflectance (specular and diffuse) of the test specimen within the wavelength range relative to barium sulfate using a Perkin-Elmer LAMBDA 9 spectrophotometer or equivalent.

Compare the reflectance value with the acceptance criteria. Aircraft and ground support equipment that use aircraft colors must comply with the "Aircraft" acceptance criteria listed in Test Methodology. Black (Color 37030 of FED-STD-595B (*Colors Used in Government Procurement*, issued December 15, 1989) or Green 383 (Color 34094 of FED-STD-595B) printing inks that will be used on labels on the exterior of ground support equipment may be required to comply with the "Ground Support Equipment" acceptance criteria in Test Methodology.

Rationale

When a marking is on the exterior of aircraft or ground support equipment, the IR reflectance of the marking can be critical. Several programs agreed that an alternative printing ink that will be used on aircraft must comply with the IR reflectance criteria in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990). The "Aircraft" acceptance criteria is that of MIL-C-85285B.

The two colors selected for ground support equipment are the only non-aircraft colors that will be used on the exterior of ground support equipment. The acceptance criteria for these colors are based on MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, amended May 21, 1993).

Test Methodology

Parameters	**Aircraft**	**Ground Support Equipment**
Number of AL1 test specimens to be tested for each candidate ink/printer system (2 labels per test specimen)	3 (*)	2 (**)
Type of Labels	Refer to Section 3.2.	Refer to Section 3.2.
Acceptance Criteria	450-500 nm ≤ 8% reflectance 500-600 nm ≤ 10% reflectance 600-2700 nm ≤ 8% reflectance	Black (37030 of FED-STD-595B) ≤ 15% reflectance at wavelengths listed in Table 6 Green 383 (34094 of FED-STD-595B): refer to Table 7

(*) One test specimen per wavelength range.
(**) One test specimen per color.

Table 6. Selected Wavelengths for Determining IR Reflectance Values of Spectrophotometric Curves for Black (37030 of FED-STD-595B) Alternative Inks for Labels (in nanometers)

714	769	816
725	773	821
730	777	826
737	783	831
742	787	836
747	793	842
751	797	848
756	802	855
760	807	862
764	811	873

Table 7. Acceptance Criteria for IR Reflectance of Green 383 (34094 of FED-STD-595B) Alternative Inks for Labels

Wavelength	**% Reflectance**	
	Maximum	**Minimum**
600	10.2	--
610, 620, 630	9.8	--
640, 650	9.5	--
660	10.0	--
670	10.5	4.0
680	13.0	5.8
690	21.5	8.5
700	28.0	11.0
710	35.8	15.0
720	41.0	19.0
730	48.5	25.0
740	51.8	30.0
750	56.0	36.3
760	59.5	40.0
770	61.5	42.0
780, 790, 800, 810, 820, 830, 840, 850, 860, 870, 880, 890, 900	--	42.0

Unique Equipment and Instrumentation

- Perkin-Elmer LAMBDA 9 spectrophotometer (or equivalent)

3.2.6. Legibility Test

Test Description

A legibility test is necessary to ensure that the alternative identification method produces a readable label.

At a lighting of at least 50 candela, examine test specimens at 18 inches minimum distance with 20/20 corrected vision. The test specimen is described in Appendix B and uses a 10 point Arial font.

Rationale

A national standard was not used to develop this test procedure. The basis of the legibility test was derived from a discussion between Lockheed Martin, Texas Instruments Defense Systems & Electronics, and the program technical representatives. The 10 point font was selected because it was perceived as a standard for typed alphanumerics on markings. The lighting intensity was selected as a number that is below the OSHA workplace minimums. The distance from the test specimen (i.e., 18 inches) was referenced to Lockheed Martin standards and, therefore, agreed upon by the group.

Test Methodology

Parameters	18 inches minimum distance; At least 50 candela
Number of AL1 test specimens to be tested for each candidate ink/printer system (2 labels per test specimen)	1 (White labels with black inks. Label color must contrast with ink color.)
Type of Labels	Refer to Section 3.2
Acceptance Criteria	Visually discernible printing with 20/20 corrected vision

3.2.7. Salt Spray Resistance Test

Test Description

This salt spray test measures the affect that corrosion has on the legibility and adhesion of a marking material. In addition, it compares the amount of corrosion that occurs on a labeled test specimen with the corrosion on a control specimen.

Perform this test in accordance with ASTM B 117-94 (*Standard Practice for Operating Salt Spray (Fog) Testing Apparatus*, approved February 15, 1994).

Place the test specimens and a control panel of AL2 (not labeled, for Part B of this test only) into a fog chamber. The test specimens may not contact the chamber walls or each other. Prepare a salt solution and the fog chamber as specified in Test Methodology. Set the nozzles in the fog chamber so that sprayed salt solution does not directly contact the test specimens.

Part A: Operate the fog chamber continuously for 48 hours. At the end of the test duration, carefully remove the specimens. Clean the specimens by gently flushing them with running tap water, and dry them with a stream of clean, compressed air. Evaluate the legibility and adhesion of the ink on the label in accordance with Section 3.2.6 and Section 3.2.2, respectively.

Part B: Operate the fog chamber continuously for 168 hours. At the end of the test duration, carefully remove the specimens. Clean the specimens by gently flushing them with running tap water, and dry them with a stream of clean, compressed air. Compare the amount of corrosion on the test specimen to that of the control specimen.

Rationale

A salt spray test is necessary because it will evaluate the additional corrosion potential created by an alternative marking material. A salt spray test is required by MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994). The test in this JTP is performed in accordance with ASTM B 117-94, which is a standard salt spray (fog) test.

The duration of Part A of this test was derived from MIL-I-43553B, which requires that an epoxy ink is functional after 48 hours immersion in 20 percent salt solution. The duration of Part B of the test (168 hours) is the

duration of a salt spray test for MIL-C-5541E (*Chemical Conversion Coatings on Aluminum and Aluminum Alloys*, issued November 30, 1990), and is used as a standard for this test because the AL2 control specimen should not corrode during this time period.

Test Methodology

Parameters	• Test specimen at a 15-30° angle • Temperature of exposed salt spray zone = 95 + 2 - 3°F • Every 80 cm^2 horizontal area, two collectors gather 1.0-2.0 mL fog/h • 5% salt solution (5 ± 1 parts by weight of NaCl in 95 parts of water) • pH = 6.5-7.2 when atomized at 95°F (35°C) • 48 and 168 hours
Number of AL1 test specimens to be tested for each candidate ink/printer system (2 labels per test specimen)	4 (*), 1 Control specimen of AL2 (not labeled, for Part B)
Type of Labels	Refer to Section 3.2
Acceptance Criteria	After 48 hours: Legibility per Section 3.2.6 and adhesion per Section 3.2.2 After 168 hours: Corrosion no worse than control specimen of AL2 (not labeled)

(*) Three test specimens for Part A (48 hour test); one test specimen for Part B (168 hour test).

Unique Equipment and Instrumentation

- Fog Chamber
- Salt Solution Reservoir
- Compressed Air Supply
- Atomizing Nozzles
- Heater for the Fog Chamber

3.2.8. Temperature Exposure and Thermal Shock Resistance Tests

Test Description

To measure the resistance of the marking to degradation upon extreme temperature exposure or thermal shock, perform three tests: low temperature exposure, high temperature exposure, and thermal shock. Note that the appropriate test temperature must be selected in accordance with the final use of the part; the temperatures used for the temperature exposure and thermal shock tests should be close to the expected service temperature.

1. **Low Temperature Exposure**. Place test specimens into a cold chamber at -55 ± 5°F or -40 ± 5°F for 30 minutes. After the test duration, remove the test specimens and inspect them within 30 minutes for legibility per Section 3.2.6 and adhesion per Section 3.2.2.

2. **High Temperature Exposure**. Place test specimens in a circulating air oven for 30 minutes. The temperature of the oven will be either 244 ± 5°F, 160 ± 5°F, or 130 ± 5°F. After the test duration, cool the test specimens at room temperature for 30 minutes. Inspect the legibility and adhesion of the ink per Section 3.2.6 and Section 3.2.2, respectively.

3. **Thermal Shock Test**. Expose the test specimen to -55 ± 5°F or -40 ± 5°F for 30 minutes in a cold chamber. Remove the test specimen from the cold chamber and transfer it to an oven at 244 ± 5°F, 160 ± 5°F, or 130 ± 5°F within one minute. Remove the test specimen from the oven after 30 minutes. Within 30 minutes after removal from the oven, inspect the marking for legibility per Section 3.2.6 and the ink for adhesion per Section 3.2.2.

Rationale

This test measures the printing ink's ability to withstand a large range of temperatures. The high and low temperature exposure tests are performed in accordance with MIL-M-87958 (*Marker Blanks, Pressure Sensitive Adhesive Wire or Cable Marker and Identification Labels*, issued October 12, 1990), Paragraphs 4.6.5.1 and 4.6.5.2, respectively. MIL-M-87958 is for wire or cable marker self-adhesive labels, and has been used for this application. The thermal shock resistance test was developed by

Lockheed Martin and technical representatives as a standard test to measure the ability of the printing ink to withstand a rapid temperature change.

The high service temperature of 244°F (118°C) was chosen to agree with MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994). The duration of the tests was reduced from the MIL-M-87958 requirement because the test specimens are simple, have low thermal mass, and would not require the 4 hour (low temperature exposure) and 168 hour (high temperature exposure) test duration to obtain the desired test specimen temperature. Thirty minute test durations are believed to be sufficient by Lockheed Martin and technical representatives.

Test Methodology

Parameters	• Low temperature exposure (-55°F or -40°F for 30 minutes) • High temperature exposure (130°F, 160°F, or 244°F for 30 minutes) • Thermal shock resistance (-55°F or -40°F for 30 minutes then 130°F, 160°F, or 244°F for 30 minutes)
Number of AL1 test specimens to be tested for each candidate ink/printer system (2 labels per test specimen)	3 (*)
Type of Labels	Refer to Section 3.2
Acceptance Criteria	Legibility per Section 3.2.6 and adhesion per Section 3.2.2

(*) One test specimen for the low temperature exposure test; one test specimen for the high temperature exposure test; and one test specimen for the thermal shock test.

Unique Equipment and Instrumentation

- Cold Chamber(s) capable of maintaining -55 ± 5°F and -40 ± 5°F
- Oven(s) capable of maintaining 130 ± 5°F, 160 ± 5°F, and 244 ± 5°F

3.2.9. UV Light/Condensation Exposure Test

Test Description

This test measures the effects of moisture, temperature, and ultraviolet (UV) light on an alternative marking material.

Perform this test in accordance with ASTM G 53-91 (*Standard Practice for Operating Light and Water-Exposure Apparatus (Fluorescent UV-Condensation Test) of Exposure of Nonmetallic Materials*, approved September 15, 1991).

Position the test specimens in the test chamber so that the labels are facing the lamp. The test specimens are exposed for a total of 96 hours using an 8-hour repeating program cycle of 4 hours of UV light at 140°F (60°C) followed by 4 hours of condensation at 122°F (50°C). Rotate the test specimens every 24 hours to ensure that all specimens spend approximately the same exposure time near the center of the exposure area. After the test duration, remove the test specimens and evaluate the ink for legibility and adhesion per Section 3.1.8 and Section 3.1.2, respectively.

Rationale

A UV light/condensation test is necessary because it identifies deleterious effects on printing inks that may be used in outside environments. A 96 hour test duration was selected because it is the lower limit specified in ASTM G 53-91 and it is expected that any detrimental effects will show up during this duration.

Test Methodology

Parameters	Total exposure of 96 hours using an 8-hour repeating program cycle of 4 hours of UV light at 140°F (60°C) followed by 4 hours of condensation at 122°F (50°C)
Number of AL1 test specimens to be tested for each candidate ink/printer system (2 labels per test specimen)	1
Type of Labels	Refer to Section 3.2
Acceptance Criteria	Label stays on test specimen; Legibility per Section 3.2.6 and adhesion per section 3.2.2

Unique Equipment and Instrumentation

- Test chamber with eight fluorescent UV lamps, a heated water pan, racks, and controls (for UV Light Test)
- Conditioning cabinets or ovens (for Condensation Test)

3.3. Test Descriptions for Self-Adhesive Labels; Testing the Labels on the Test Specimens

Test procedures that should be performed to test polyimide, polyester, polyvinyl fluoride, and paper labels from selected vendors are described in Sections 3.3.1 through 3.3.8. Each test specimen will contain two blank (unmarked) labels of the same material and from the same vendor. Refer to Appendix C for the required orientation of all test specimens for this Section. Failure of the underlying test specimens that are not shared with the labels shall not be considered evidence of failure of the labels.

3.3.1. Adhesion Test

Test Description

This adhesion test will measure the ability of a label to adhere to a substrate. The adhesion of the candidate labels will be tested with a peel test.

Perform this test in accordance with Test Method A of ASTM D 3330-90 (*Standard Test Methods for Peel Adhesion of Pressure-Sensitive Tape at 180° Angle*, approved June 29, 1990).

Apply the labels to the test coupons as in Appendix C, without adhering one of the narrow ends of each label. Double back the free end of the tape at an angle of 180° for approximately one inch of the label. Clamp the lower jaw of the adhesion tester to the test specimen and the upper jaw to the free end of the label. Operate the lower jaw at 12 inches per minute. Record the average pull value obtained during the next two inches.

Rationale

ASTM D 3330-90 was chosen for the measurement of adhesion of a label to a substrate because it is the most common standard in industry. An average acceptance criteria was determined from label vendor specifications.

Test Methodology

Parameters	Peel test
Number and type of Test Specimens per type of label (2 labels per test specimen)	5 AL1, 5 AL2, 5 SS, 5 NR, 5 SR, 5 G/E, 5 C/E, 5 A/E (*)
Type of labels to be tested	Polyimide, polyester, polyvinyl fluoride, and paper
Acceptance Criteria	Average pull value at least 16 ounces per linear inch

(*) As an extended requirement, labels will also be applied to 3 Javelin Launch Tubes that are appropriately primed and then coated with a topcoat that conforms to MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993) and to 3 Javelin Launch Tubes that are appropriately primed and then coated with a topcoat that conforms to MIL-C-53039A (*Chemical Agent Resistant Single-Component Aliphatic Polyurethane Coating*, issued May 19, 1993).

Unique Equipment and Instrumentation

- Adhesion tester per ASTM D 3330-90

3.3.2. Chemical Resistance Test

Test Description

This test examines the adhesion of labels after exposure to selected chemicals.

Part A: Perform this chemical resistance test in accordance with ASTM D 896-92 (*Resistance of Adhesive Bonds to Chemical Reagents*, approved July 15, 1992), but replace the chemical reagents in the standard with those listed in Test Methodology.

Immerse test specimens in reagents as specified in Test Methodology. Recover and dry the specimens. Test the label for adhesion per Section 3.3.1.

Part B: Coat a new set of test specimens with a thin film of RMA flux. Float the test specimens in a solder bath and immerse in a terpene-based solvent as specified in Test Methodology. After immersion,

evaluate the specimens for adhesion in accordance with Section 3.3.1. This test is patterned after Section 4.6.3.2.1 of MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994) to measure the hot solder/flux chemical resistance.

Rationale

The first part of this procedure is patterned after ASTM D 896-92. The selection of the chemical reagents was based on Test Method 215J of MIL-STD-202F (*Test Methods for Electronic and Electrical Component Parts*, issued January 31, 1996). MIL-STD-202F specifies isopropyl alcohol and deionized water. In addition, Lockheed Martin commonly uses isopropyl alcohol and deionized water for cleaning. Engine oil was added because it is representative of petroleum products used around Lockheed Martin's products. Engine oil was also added because it is used in qualification testing by Critchley Inc., a label vendor. The chemical reagents listed for the extended tests (refer to Test Methodology) were identified by at least one program as a requirement.

The second part of this test procedure is performed in accordance with Section 4.6.3.2.1 of MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994) to measure the hot solder/flux chemical resistance, except the specimens are immersed in a terpene-based solvent for 3 minutes instead of 1 minute. The terpene-based solvent soak was increased from the 1 minute specified by MIL-I-43553B to 3 minutes to be consistent with the first part of the chemical soak test that is performed in accordance with ASTM D 896-92.

Test Methodology

Parameters	Part A: Immerse test specimens for 3 minutes at 23 ± 1.1°C (73.4 ± 2°F) in the following fluids: • Common tests: Isopropyl alcohol, deionized water, or engine oil (21SAE20W) • Extended tests: Coolanol, PAO, hydraulic fluid (MIL-H-5606), lubricating oil (MIL-L-23699), Skydrol, JP5 (MIL-T-5624), or DS2
Parameters (continued)	Part B: • Float specimen, marking side up, on solder bath at 260 ± 5°C (500 ± 9°F) for 10 seconds • Cool to room temperature • Immerse in terpene-based solvent for 3 minutes
Number and type of Test Specimens per type of label (2 labels per test specimen)	1 AL1, 1 AL2, 1 SS, 1 NR, 1 SR, 1 G/E, 1 C/E, 1 A/E (per chemical)
Type of labels to be tested	Polyimide, polyester, polyvinyl fluoride, and paper
Acceptance Criteria	Adhesion per Section 3.3.1 Inspect visually for discoloration, wrinkling, or cracking of the label

3.3.3. Corrosivity Test

Test Description

This test determines if a label is corrosive to a metal substrate.

Perform this test procedure in accordance with ASTM D 3310-90 (*Standard Test Method for Determining Corrosivity of Adhesive Materials*, approved March 30, 1990).

Heat an oven to one of the temperatures listed in Test Methodology, choosing the temperature that is closest to the expected service temperature. Place the test specimen into a glass jar. Place uncovered jar in a larger glass jar and screw a jar lid onto the larger jar. Heat jars in an oven for 7 days. At the end of the test duration, pull the label off of the test specimen and visually inspect the metal surface for corrosion.

Rationale

This corrosivity test is an extended test for programs that require a test for corrosivity in addition to the salt spray resistance test in Section 3.3.6. This corrosivity test is patterned after ASTM D 3310-90. The highest service temperature of 244°F (118°C) was chosen to agree with MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994).

Test Methodology

Parameters	7 days at 244 ± 5°F, 160 ± 5°F, or 130 ± 5°F
Number and type of Test Specimens per type of label (2 labels per test specimen)	1 AL1, 1 AL2, 1 SS
Type of labels to be tested	Polyimide, polyester, polyvinyl fluoride, and paper
Acceptance Criteria	Adhesion per Section 3.3.1. No visible signs of corrosion

Unique Equipment and Instrumentation

- Glass jars with screw caps and cups or open jars
- Forced Draft Circulating Air Oven

3.3.4. DC Electrical Resistance Test

Test Description

Measuring the electrical resistance of labels ensures that the labels will not create short circuits between electronic components.

Perform this DC electrical resistance test in accordance with ASTM D 257-92 (*Standard Test Method for D-C Resistance or Conductance of Insulating Materials*, approved June 15, 1992, re-issued December 1992).

Mount the test specimen in a test chamber and apply 500 ± 5 V to the specimen for 60 seconds. Directly measure the voltage drop across the label with a current-measuring device (e.g., electrometer, DC amplifier with indicating meters, or galvanometer). Calculate the surface and volume resistivity using the measured voltage drop and the specimen and electrode dimensions. The test environment should be at standard

conditions (25 ± 5°C and relative humidity of 50 ± 20 percent). Note that surface contamination will affect the results of this test, so it is important to use the cleanliness test specified in Section 3.

Rationale

This test is performed in accordance with ASTM D 257-92. The test methodology is similar to the test methodology of Paragraph 4.6.2.4 of MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994). Volume resistance is calculated in addition to surface resistance because some degree of volume resistance is always involved.

Test Methodology

Parameters	500 ± 5 V for 60 seconds
Number and type of Test Specimens per type of label (2 labels per test specimen)	1 G/E, 1 C/E, 1 A/E
Type of labels to be tested	Polyimide, polyester, polyvinyl fluoride, and paper
Acceptance Criteria	Resistance ≥ 10^{12} ohms

Unique Equipment and Instrumentation

- Power source
- Current measuring device (e.g., electrometer, DC amplifier with indicating meters, or galvanometer)

3.3.5. IR Reflectance Test

Test Description

This testing method measures the infrared (IR) reflectance of a label.

Measure the total reflectance (specular and diffuse) of the blank labels on the test specimen within the wavelength range relative to barium sulfate using a Perkin-Elmer LAMBDA 9 spectrophotometer or equivalent.

Compare the reflectance value with the acceptance criteria. Aircraft and ground support equipment that use aircraft colored labels must comply with the "Aircraft" acceptance criteria listed in Test Methodology. Black (Color 37030 of FED-STD-595B (*Colors Used in Government*

Procurement, issued December 15, 1989) or Green 383 (Color 34094 of FED-STD-595B) labels that will be used on the exterior of ground support equipment may be required to comply with the "Ground Support Equipment" acceptance criteria in Test Methodology.

Rationale

When a marking is on the exterior of aircraft and ground support equipment, the IR reflectance of the label can be critical. Several programs agreed that labels that will be used on aircraft must comply with the IR reflectance criteria in MIL-C-85285B (*High-Solids Polyurethane Coating*, issued October 22, 1990). The "Aircraft" acceptance criteria is that of MIL-C-85285B. Note that in cases where IR reflectance is critical, gray labels or other dark-colored labels will typically be used.

The two colors selected for ground support equipment are the only non-aircraft colors that will be used on the exterior of ground support equipment. The acceptance criteria for these colors are based on MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993).

Test Methodology

Parameters	**Aircraft**	**Ground Support Equipment**
Number and type of Test Specimens per type of label (2 labels per test specimen)	3 AL1 (*)	2 AL1 (**)
Type of labels to be tested	Polyimide, polyester, polyvinyl fluoride, and paper	Polyimide, polyester, polyvinyl fluoride, and paper

Test Methodology (continued)

Acceptance Criteria	450-500 nm ≤ 8% reflectance 500-600 nm ≤ 10% reflectance 600-2700 nm ≤ 8% reflectance	Black (37030 of FED-STD-595B) ≤ 15% reflectance at wavelengths listed in Table 8 Green 383 (34094 of FED-STD-595B): refer to Table 9

(*) One test specimen per wavelength range.
(**) One test specimen per color.

Table 8. Selected Wavelengths for Determining IR Reflectance Values of Spectrophotometric Curves for Black (37030 of FED-STD-595B) Alternative Labels (in nanometers)

714	769	816
725	773	821
730	777	826
737	783	831
742	787	836
747	793	842
751	797	848
756	802	855
760	807	862
764	811	873

Table 9. Acceptance Criteria for IR Reflectance of Green 383 (34094 of FED-STD-595B) Alternative Labels

Wavelength	% Reflectance	
	Maximum	Minimum
600	10.2	--
610, 620, 630	9.8	--
640, 650	9.5	--
660	10.0	--
670	10.5	4.0
680	13.0	5.8
690	21.5	8.5
700	28.0	11.0
710	35.8	15.0
720	41.0	19.0
730	48.5	25.0
740	51.8	30.0
750	56.0	36.3
760	59.5	40.0
770	61.5	42.0
780, 790, 800, 810, 820, 830, 840, 850, 860, 870, 880, 890, 900	--	42.0

Unique Equipment and Instrumentation

- Perkin-Elmer LAMBDA 9 spectrophotometer (or equivalent)

3.3.6. Salt Spray Resistance Test

Test Description

This salt spray test measures the effect that corrosion has on the adhesion of a label. In addition, it compares the amount of corrosion that occurs on a labeled test specimen with the corrosion on a control specimen (an unlabeled AL2 test specimen).

Perform this test in accordance with ASTM B 117-94 (*Standard Practice for Operating Salt Spray (Fog) Testing Apparatus*, approved February 15, 1994).

Place the test specimens and a control panel of AL2 (not labeled, for Part B of this test only) into a fog chamber. The test specimens may not contact the chamber or each other. Prepare a salt solution and the fog chamber as specified in Test Methodology. Set the nozzles in the fog chamber so that sprayed salt solution does not directly contact the test specimens.

Part A: Operate the fog chamber continuously for 48 hours. At the end of the test duration, carefully remove the specimens. Clean the specimens by gently flushing them with running tap water, and dry them with a stream of clean, compressed air. Evaluate the adhesion of the label in accordance with Section 3.3.1.

Part B: Operate the fog chamber continuously for 168 hours. At the end of the test duration, carefully remove the specimens. Clean the specimens by gently flushing them with running tap water, and dry them with a stream of clean, compressed air. Compare the amount of corrosion on the test specimens to that of the control specimen.

Rationale

A salt spray test is necessary because it will evaluate the additional corrosion potential created by a label. A salt spray test is required by MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994). The test in this JTP is performed in accordance with ASTM B 117-94, which is a standard salt spray (fog) test.

The duration of Part A of this test was derived from MIL-I-43553B, which requires that an epoxy ink is functional after 48 hours immersion in 20 percent salt solution. The duration of Part B of the test (168 hours) is the duration of a salt spray test for MIL-C-5541E (*Chemical Conversion Coatings on Aluminum and Aluminum Alloys*, issued November 30, 1990), and is used as a standard for this test because the AL2 control specimen should not corrode during this time period.

Test Methodology

Parameters	• Test specimen at a 15-30° angle • Temperature of exposed salt spray zone = 95 + 2 - 3°F • Every 80 cm^2 horizontal area, two collectors gather 1.0-2.0 mL fog/h • 5% salt solution (5 ± 1 parts by weight of NaCl in 95 parts of water) • pH = 6.5-7.2 when atomized at 95°F (35°C) • 48 and 168 hours
Number and type of Test Specimens per type of label (2 labels per test specimen)	4 AL1 (*), 4 AL2 (*), 4 SS (*), 1 Control specimen of AL2 (not labeled, for Part B only)
Type of labels to be tested	Polyimide, polyester, polyvinyl fluoride, and paper
Acceptance Criteria	After 48 hours: Adhesion per Section 3.3.1. No affects on label (visual inspection) After 168 hours: Corrosion no worse than control specimen of AL2 (not labeled)

(*) Three test panels for Part A (48 hour test); one test panel for Part B (168 hour test).

Unique Equipment and Instrumentation

- Fog Chamber
- Salt Solution Reservoir
- Compressed Air Supply
- Atomizing Nozzles
- Heater for the Fog Chamber

3.3.7. Temperature Exposure and Thermal Shock Resistance Tests

Test Description

To measure the resistance of the labels to degradation upon extreme temperature exposure or thermal shock, perform three tests: low temperature exposure, high temperature exposure, and thermal shock. Note that the appropriate test temperature must be selected in accordance with the final use of the part; the temperatures used for the temperature

exposure and thermal shock tests should be close to the expected service temperature.

1. **Low Temperature Exposure**. Place test specimens into a cold chamber at -55 ± 5°F or -40 ± 5°F for 30 minutes. After the test duration, remove the test specimens and inspect them within 30 minutes for adhesion per Section 3.3.1.

2. **High Temperature Exposure**. Place test specimens in a circulating air oven for 30 minutes. The temperature of the oven will be either 244 ± 5°F, 160 ± 5°F, or 130 ± 5°F. After the test duration, cool the test specimens at room temperature for 30 minutes. Evaluate the adhesion of the label per Section 3.3.1.

3. **Thermal Shock Test**. Expose the test specimen to -55 ± 5°F or -40 ± 5°F for 30 minutes in a cold chamber. Remove the test specimen from the cold chamber and transfer them to an oven at 244 ± 5°F, 160 ± 5°F, or 130 ± 5°F within one minute. Remove the test specimen from the oven after 30 minutes. Within 30 minutes after removal from the oven, inspect the label for adhesion per Section 3.3.1.

Rationale

This test measures the label's ability to withstand a large range of temperatures. The high and low temperature exposure tests are performed in accordance with MIL-M-87958 (*Marker Blanks, Pressure Sensitive Adhesive Wire or Cable Marker and Identification Labels*, issued October 12, 1990), Paragraphs 4.6.5.1 and 4.6.5.2, respectively. MIL-M-87958 is for wire or cable marker self-adhesive labels, and may be used for this application. The thermal shock resistance test was developed by Lockheed Martin and technical representatives as a standard test to measure the ability of the label to withstand a rapid temperature change.

The high service temperature of 244°F (118°C) was chosen to agree with MIL-I-43553B (*Epoxy Base Marking Ink*, issued June 23, 1994). The duration of the tests was reduced from the MIL-M-87958 requirement because the test specimens are simple, have low thermal mass, and would not require the 4 hour (low temperature exposure) and 168 hour (high temperature exposure) test duration to obtain the desired test specimen temperature. Thirty minute test durations are believed to be sufficient by Lockheed Martin and technical representatives. Additionally, a corrosivity

test (Section 3.3.3) is available for a high temperature resistance test with a longer duration.

Test Methodology

Parameters	• Low temperature exposure (-55°F or -40°F for 30 minutes) • High temperature exposure (130°F, 160°F, or 244°F for 30 minutes) • Thermal shock resistance (-55°F or -40°F for 30 minutes then 130°F, 160°F, or 244°F for 30 minutes)
Number and type of Test Specimens per type of label (2 labels per test specimen)	3 AL1 (*) (**)
Type of labels to be tested	Polyimide, polyester, polyvinyl fluoride, and paper
Acceptance Criteria	Adhesion per Section 3.3.1

(*) One test specimen for the low temperature exposure test; one test specimen for the high temperature exposure test; and one test specimen for the thermal shock test.

(**) As an extended requirement, labels will also be applied to 2 Javelin Launch Tubes that are appropriately primed and then coated with a topcoat that conforms to MIL-C-46168D (*Chemical Agent Resistant Aliphatic Polyurethane Coating*, issued May 21, 1993) and to 2 Javelin Launch Tubes that are appropriately primed and then coated with a topcoat that conforms to MIL-C-53039A (*Chemical Agent Resistant Single-Component Aliphatic Polyurethane Coating*, issued May 19, 1993).

Unique Equipment and Instrumentation

- Cold chamber(s) capable of maintaining -55 ± 5°F and -40 ± 5°F
- Oven(s) capable of maintaining 130 ± 5°F, 160 ± 5°F, and 244 ± 5°F

3.3.8. UV Light/Condensation Exposure Test

Test Description

This test measures the effects of moisture, temperature, and ultraviolet (UV) light on labels.

Perform this test in accordance with ASTM G 53-91 (*Standard Practice for Operating Light and Water-Exposure Apparatus (Fluorescent UV-Condensation Test) of Exposure of Nonmetallic Materials*, approved September 15, 1991).

Position the test specimens in the test chamber so that the labels are facing the lamp. The test specimens are exposed for a total of 96 hours using an 8-hour repeating program cycle of 4 hours of UV light at 140°F (60°C) followed by 4 hours of condensation at 122°F (50°C). Rotate the test specimens every 24 hours to ensure that all specimens spend approximately the same exposure time near the center of the exposure area. After the test duration, remove the test specimens and evaluate the labels for adhesion per Section 3.3.1.

Rationale

A UV light/condensation test is necessary because UV light can potentially react with the chemicals in the label adhesive, causing potential failure. A 96 hour test duration was selected because it is the lower limit specified in ASTM G 53-91 and it is expected that any detrimental affects will show up during this duration.

Test Methodology

Parameters	Total exposure of 96 hours using an 8-hour repeating program cycle of 4 hours of UV light at 140°F (60°C) followed by 4 hours of condensation at 122°F (50°C)
Number and type of Test Specimens per type of label (2 labels per test specimen)	3 AL1
Type of labels to be tested	Polyimide, polyester, polyvinyl fluoride, and paper
Acceptance Criteria	Adhesion per Section 3.3.1

Unique Equipment and Instrumentation

- Test chamber with eight fluorescent UV lamps, a heated water pan, racks, and controls (for UV Light Test)
- Conditioning cabinets or ovens (for Condensation Test)

Data Analysis

- Measure and record the UV transmissibility.

4. REFERENCE DOCUMENTS

The following documents in Table 10 were referenced in the development of this Joint Test Protocol.

Table 10. Reference Documents

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
Abrasion (Scrub) Resistance	3.1.1 3.2.1	MIL-M-81531	Marking of Electrical Insulating Materials (May 2, 1967)	4.6.2
Adhesion	3.1.2 3.2.2 3.3.1	ASTM D 3359-92a ASTM D 3330-90	Standard Test Methods for Measuring Adhesion by Tape Test (May 15, 1992) Standard Test Methods for Peel Adhesion of Pressure-Sensitive Tape at 180° Angle (June 29, 1990)	
Chemical Resistance	3.1.3 3.2.3 3.3.2	ASTM D 896-92 MIL-I-43553B	Resistance of Adhesive Bonds to Chemical Reagents (July 15, 1992) Epoxy Base Marking Ink (June 23, 1994)	 4.6.3.2.1
Corrosivity	3.1.4 3.3.3	ASTM D 3310-90	Standard Test Method for Determining Corrosivity of Adhesive Materials (March 30, 1990)	
DC Electrical Resistance	3.1.5 3.3.4	ASTM D 257-92	Standard Test Method for D-C Resistance of Insulating Materials (December 1992)	12.3
Fungus Resistance	3.1.6 3.2.4	MIL-STD-810E MIL-HDBK-454	Department of Defense Test Method Standard for Environmental Considerations and Laboratory Tests (July 14, 1989) General Guidelines for Electronic Equipment (April 28, 1995)	Method 508 Guideline 4

Table 10. Reference Documents (continued)

JTP Requirement	JTP Section Cross-Reference	Reference Document	Title	Applicable Section(s) of Reference Document
IR Reflectance	3.1.7 3.2.5 3.3.5	MIL-C-85285B MIL-C-46168D	High-Solids Polyurethane Coating (October 22, 1990) Chemical Agent Resistant Aliphatic Polyurethane Coating (May 21, 1993)	3.7.4 and 4.6.6
Legibility	3.1.8 3.2.6	None	--	
Salt Spray Resistance	3.1.9 3.2.7 3.3.6	ASTM B 117-94	Standard Practice for Operating Salt Spray (Fog) Testing Apparatus (February 15, 1994)	
Temperature Exposure and Thermal Shock Resistance	3.1.10 3.2.8 3.3.7	MIL-M-87958	Marker Blanks, Pressure Sensitive Adhesive Wire or Cable Marker and Identification Labeling (October 12, 1990)	4.6.5.1 and 4.6.5.2
UV Light/ Condensation	3.1.11 3.2.9 3.3.8	ASTM G 53-91	Standard Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials (September 15, 1991)	

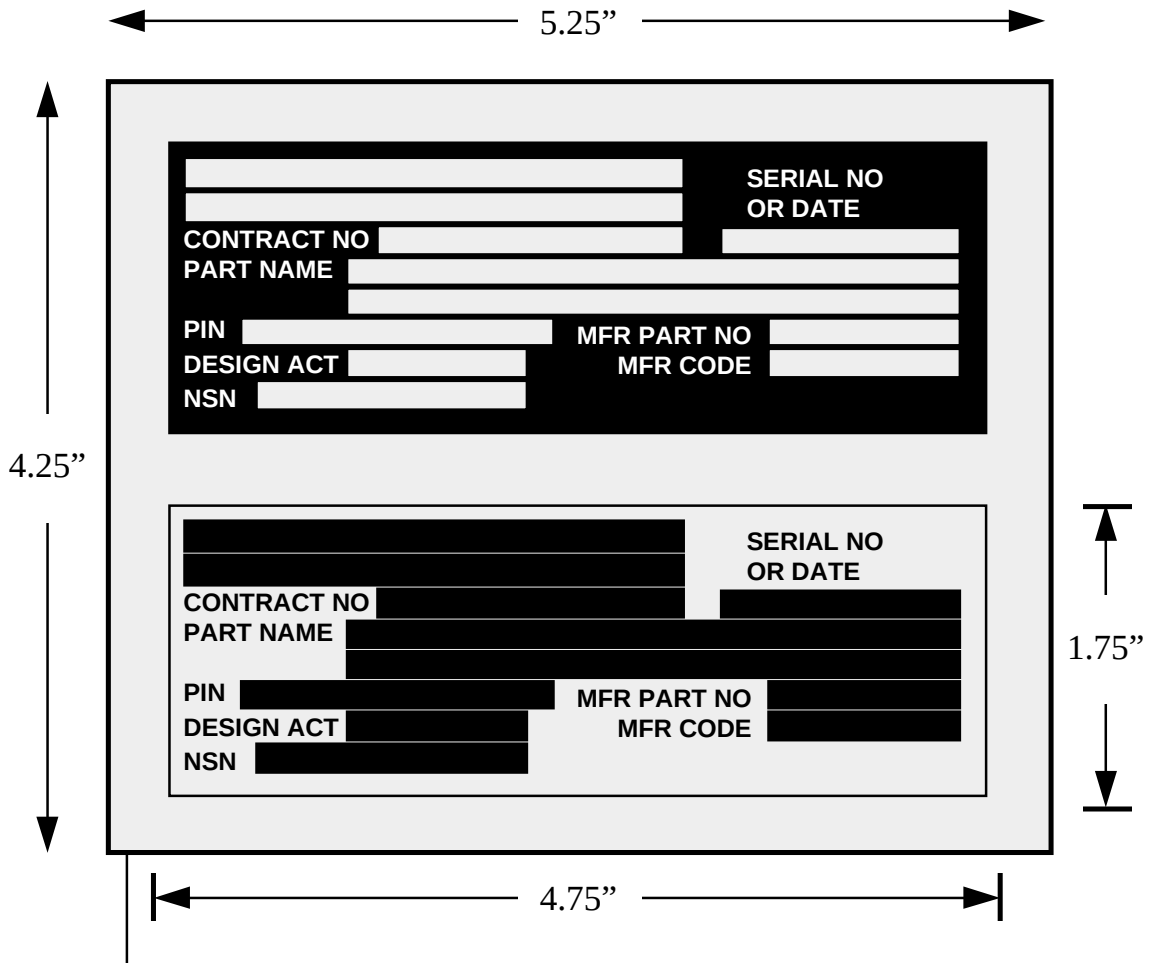
APPENDIX A

STANDARD TEST SPECIMEN
FOR TESTING ALTERNATIVE INKS

The size of the test specimen may be increased to standard coupon dimensions; however, specimens for all tests shall be of the same dimensions.

STANDARD TEST SPECIMEN
FOR TESTING ALTERNATIVE INKS

(JTP SECTION 3.1)



Note: Black area represents marked (ink-covered) area

APPENDIX B

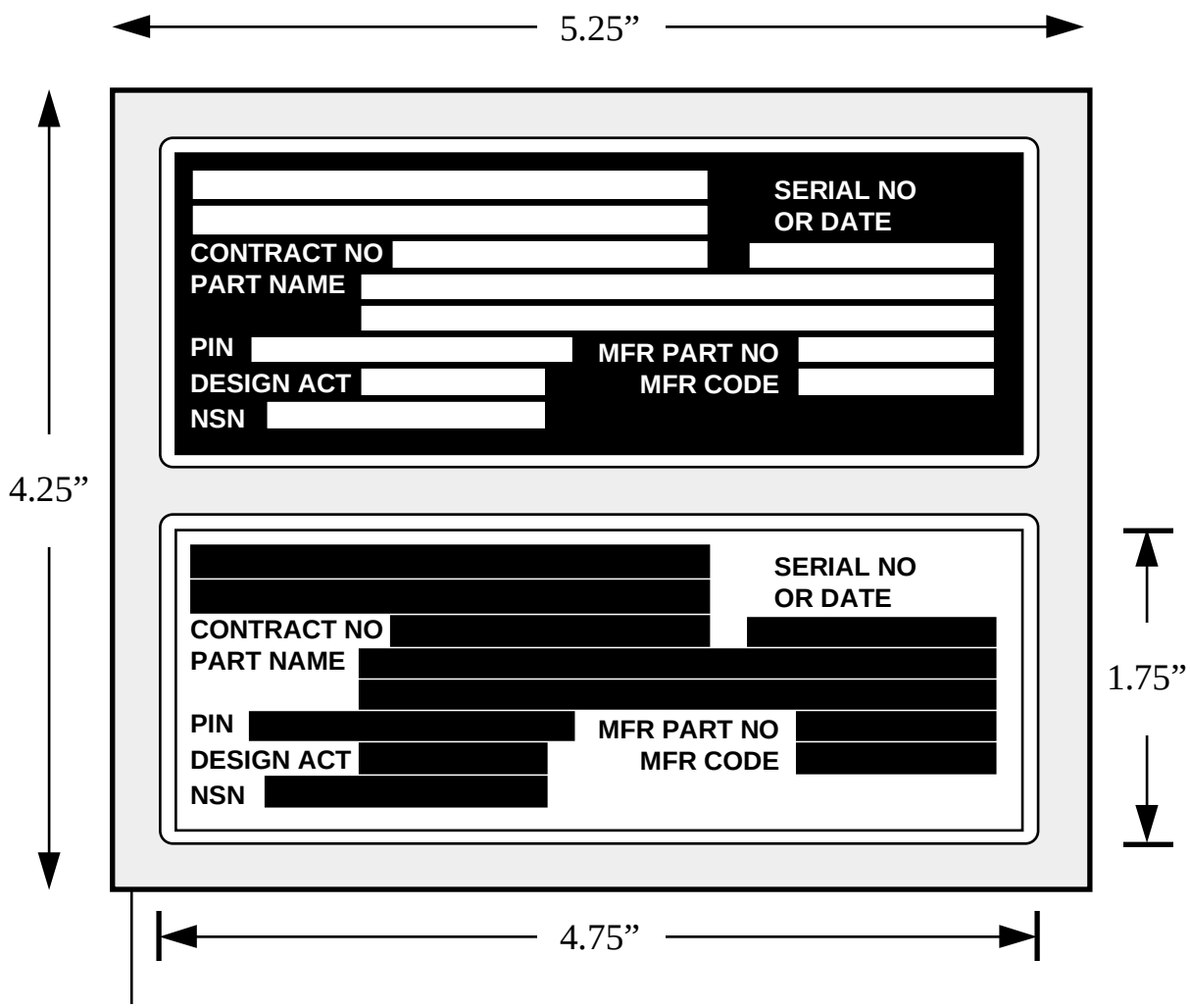
STANDARD TEST SPECIMEN
FOR TESTING INKS ON SELF-ADHESIVE LABELS

(JTP SECTION 3.2)

The size of the test specimen may be increased to standard coupon dimensions; however, specimens for all tests shall be of the same dimensions.

STANDARD TEST SPECIMEN
FOR TESTING INKS ON SELF-ADHESIVE LABELS

(JTP SECTION 3.2)



Test Specimen

Note: Black area represents marked (ink-covered) area

APPENDIX C

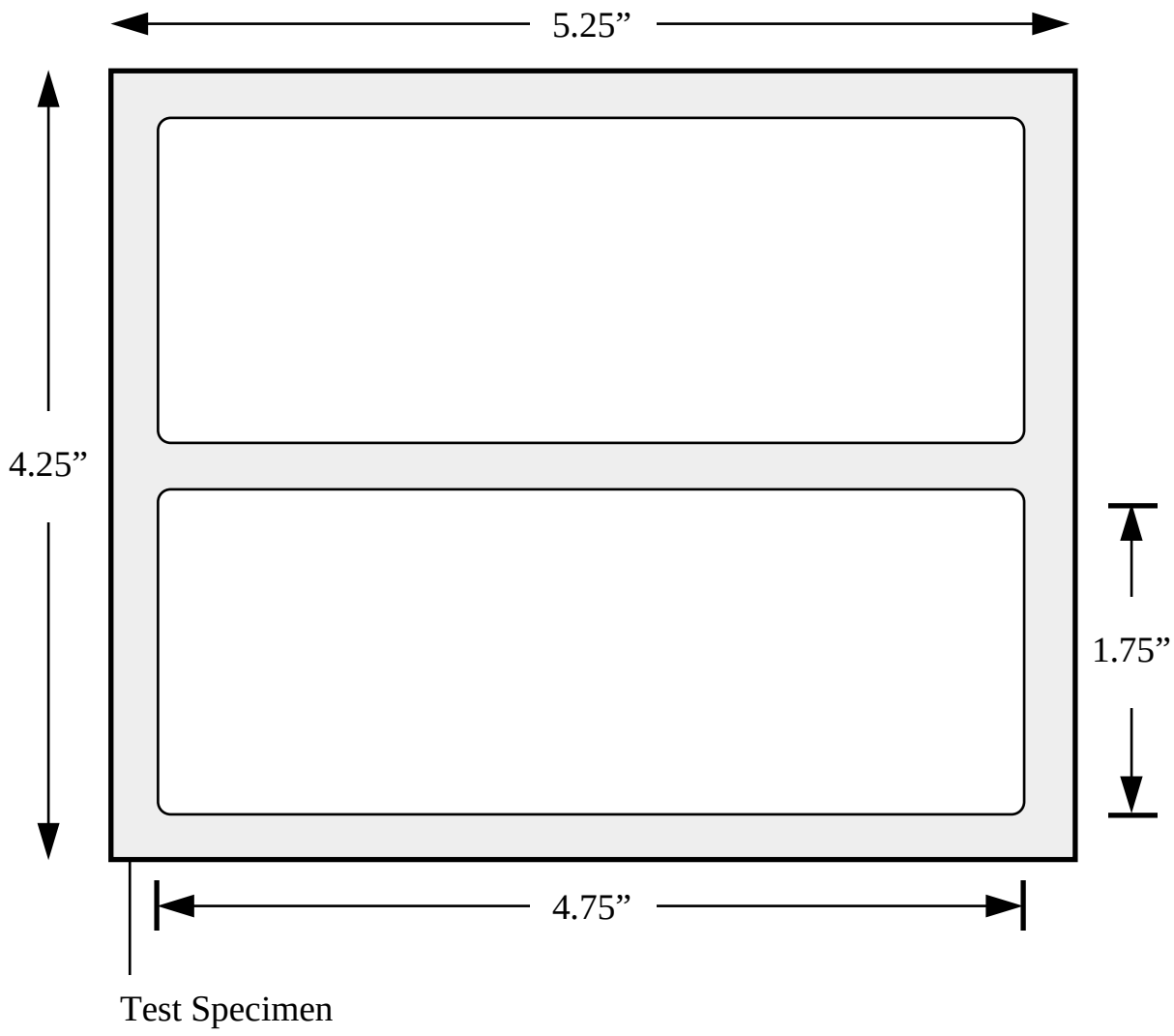
STANDARD TEST SPECIMEN
FOR TESTING SELF-ADHESIVE LABELS ON SUBSTRATES

(JTP SECTION 3.3)

The size of the test specimen may be increased to standard coupon dimensions; however, specimens for all tests shall be of the same dimensions.

STANDARD TEST SPECIMEN
FOR TESTING SELF-ADHESIVE LABELS ON SUBSTRATES

(JTP SECTION 3.3)



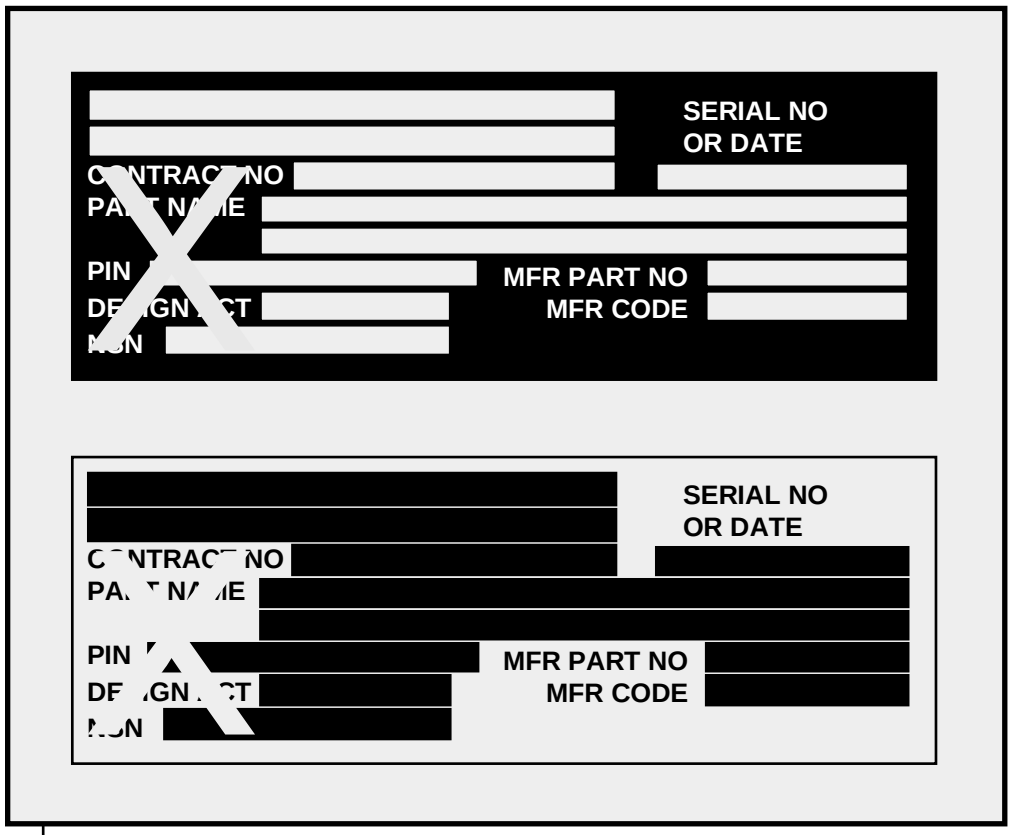
APPENDIX D

REPRESENTATIONS OF "X" MARKING FOR TESTING ADHESION OF STENCILING INKS

(JTP SECTION 3.1.2)

REPRESENTATIONS OF "X" MARKING
FOR TESTING ADHESION OF STENCILING INKS

(JTP SECTION 3.1.2)



Test Specimen

Note: "X" on the test specimen refers to the scribed marking. Refer to Section 3.1.2 for a description of the adhesion test.

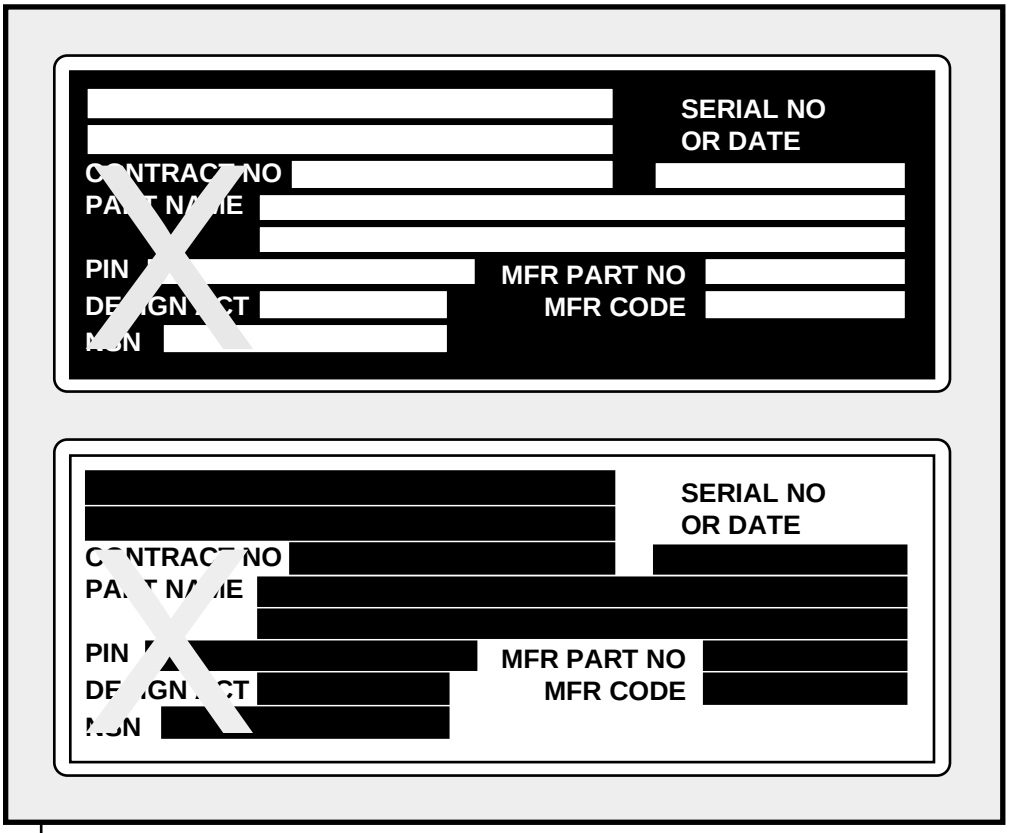
APPENDIX E

REPRESENTATIONS OF "X" MARKING FOR TESTING ADHESION OF PRINTING INKS

(JTP SECTION 3.2.2)

REPRESENTATIONS OF "X" MARKING
FOR TESTING ADHESION OF PRINTING INKS

(JTP SECTION 3.2.2)



Test Specimen

Note: "X" on the test specimen refers to the scribed marking. Refer to Section 3.2.2 for a description of the adhesion test.